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Ohta et al.

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(45) **Date of Patent: Aug. 23, 2016**

(54) **RADIO RESOURCE SETTING METHOD, BASE STATION, RADIO RESOURCE SETTING SYSTEM, AND NON-TRANSITORY COMPUTER READABLE MEDIUM**

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(73) Assignee: **NEC CORPORATION**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(51) **Int. Cl.**

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H04W 72/04	(2009.01)
H04W 16/04	(2009.01)
H04W 24/08	(2009.01)
H04W 84/04	(2009.01)
H04W 28/16	(2009.01)

(52) **U.S. Cl.**
CPC ***H04W 72/0446*** (2013.01); ***H04W 16/04*** (2013.01); *H04W 24/08* (2013.01); *H04W 28/16* (2013.01); *H04W 84/042* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

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WO	2012/105391	A1	8/2012

OTHER PUBLICATIONS

Bin Fan et al., "A Dynamic Resource Allocation Scheme Based on Soft Frequency Reuse for OFDMA Systems", IEEE 2007 International Symposium on Microwave, Antenna, Propagation and EMC Technologies for Wireless Communications, pp. 121-125, Aug. 2007.

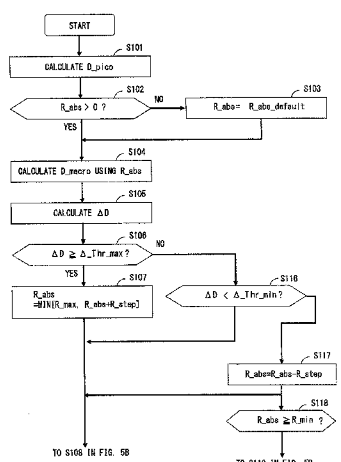
(Continued)

Primary Examiner — Minh-Trang Nguyen

(57) **ABSTRACT**

The method is a method of setting radio resources which a pico base station (**100**) and a macro base station (**200**) can use for wireless communication with a terminal, and includes obtaining loads the pico base station (**100**) and the macro base station (**200**), calculating a first delay index of the pico base station using the load of the pico base station (**100**), calculating using the load of the macro base station (**200**) a second delay index of the macro base station (**200**) in case where the macro base station (**200**) has set radio resources whose use is limited, and calculating a ratio of the radio resources whose use is limited by the macro base station (**200**) based on the first and second delay indices, and setting the radio resources whose use is limited in the second communication area using the ratio of the radio resources whose use is limited.

25 Claims, 15 Drawing Sheets



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3GPP TS 36.300 V10.6.0 (Dec. 2011), 3GPP TSG RAN E-Utra and E-Utran Overall description Stage 2 (Release 10), p. 116, Dec. 2011.

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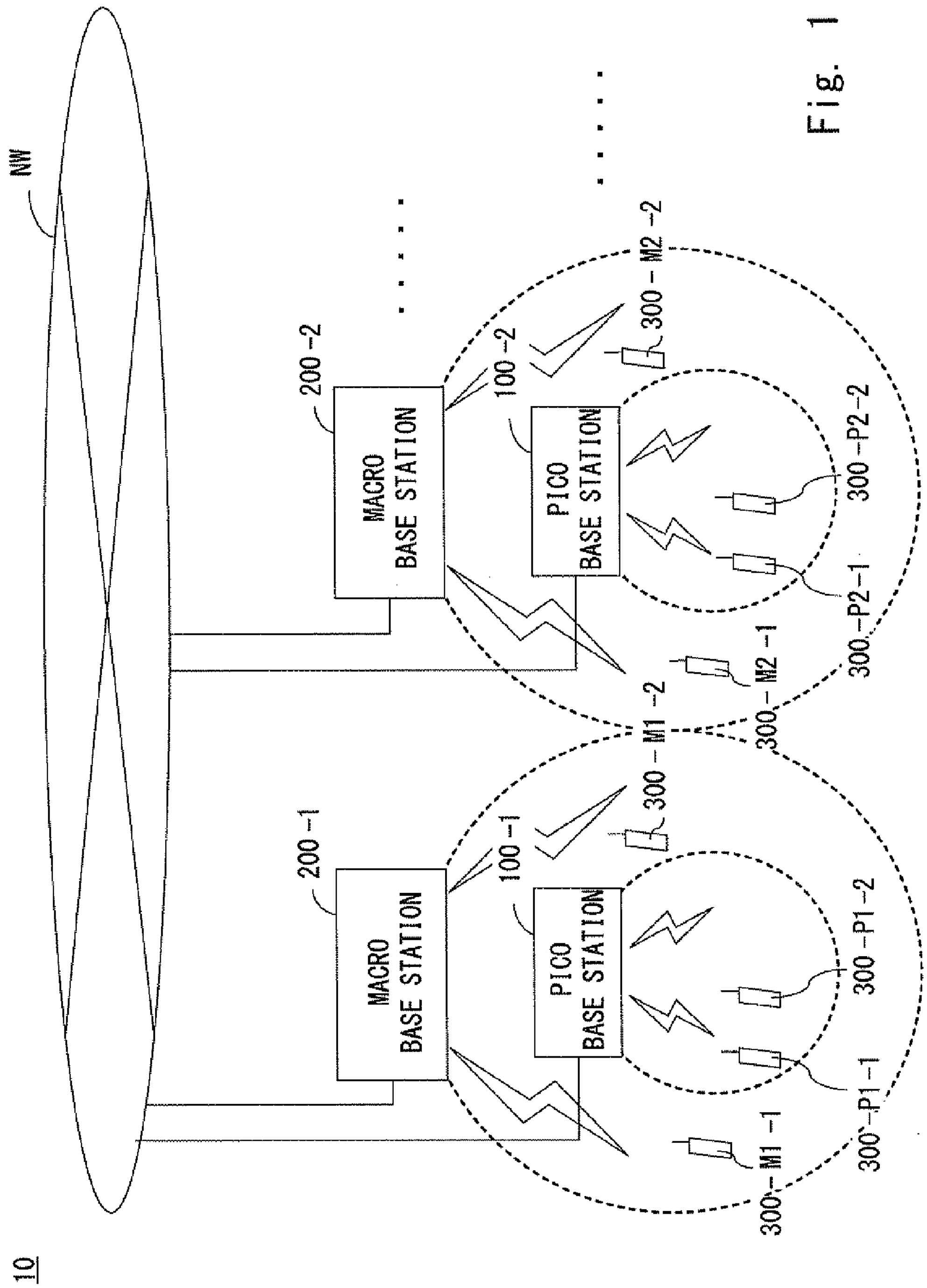
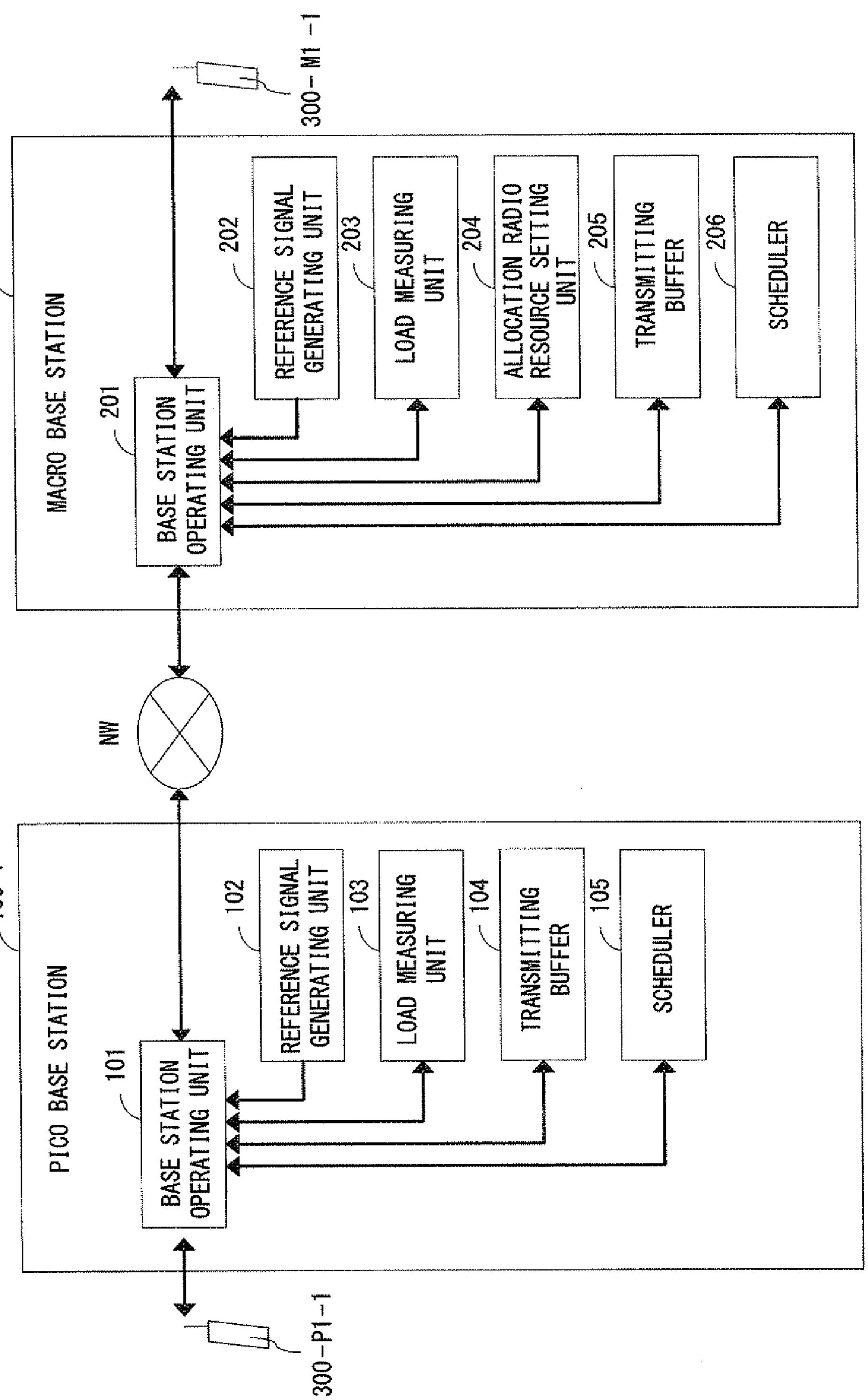

10
NW
200-1
200-2
MACRO BASE STATION
MACRO BASE STATION
100-1
100-2
PICO BASE STATION
PICO BASE STATION
300-M1-1
300-M1-2
300-M2-1
300-M2-2
300-P1-1
300-P1-2
300-P2-1
300-P2-2

Fig. 1

Fig. 2


300-M1-1
200-1
MACRO BASE STATION
201
BASE STATION OPERATING UNIT
202
REFERENCE SIGNAL GENERATING UNIT
203
LOAD MEASURING UNIT
204
ALLOCATION RADIO RESOURCE SETTING UNIT
205
TRANSMITTING BUFFER
206
SCHEDULER
NW
100-1
PICO BASE STATION
101
BASE STATION OPERATING UNIT
102
REFERENCE SIGNAL GENERATING UNIT
103
LOAD MEASURING UNIT
104
TRANSMITTING BUFFER
105
SCHEDULER
300-P1-1

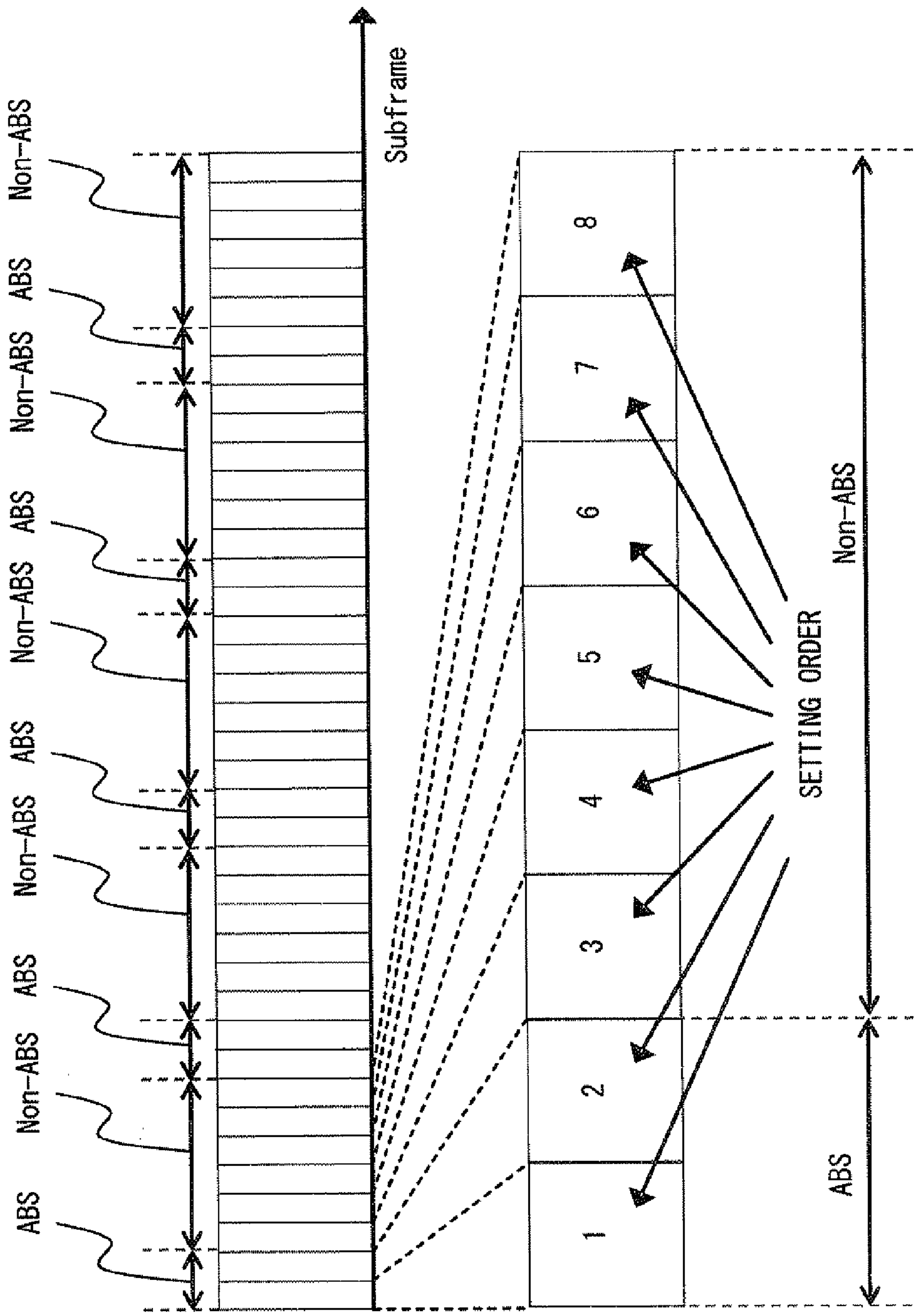

Subframe
Non-ABS
ABS
Non-ABS
ABS
Non-ABS
ABS
Non-ABS
ABS
Non-ABS
ABS
1
2
3
4
5
6
7
8
SETTING ORDER
ABS
Non-ABS

Fig. 3

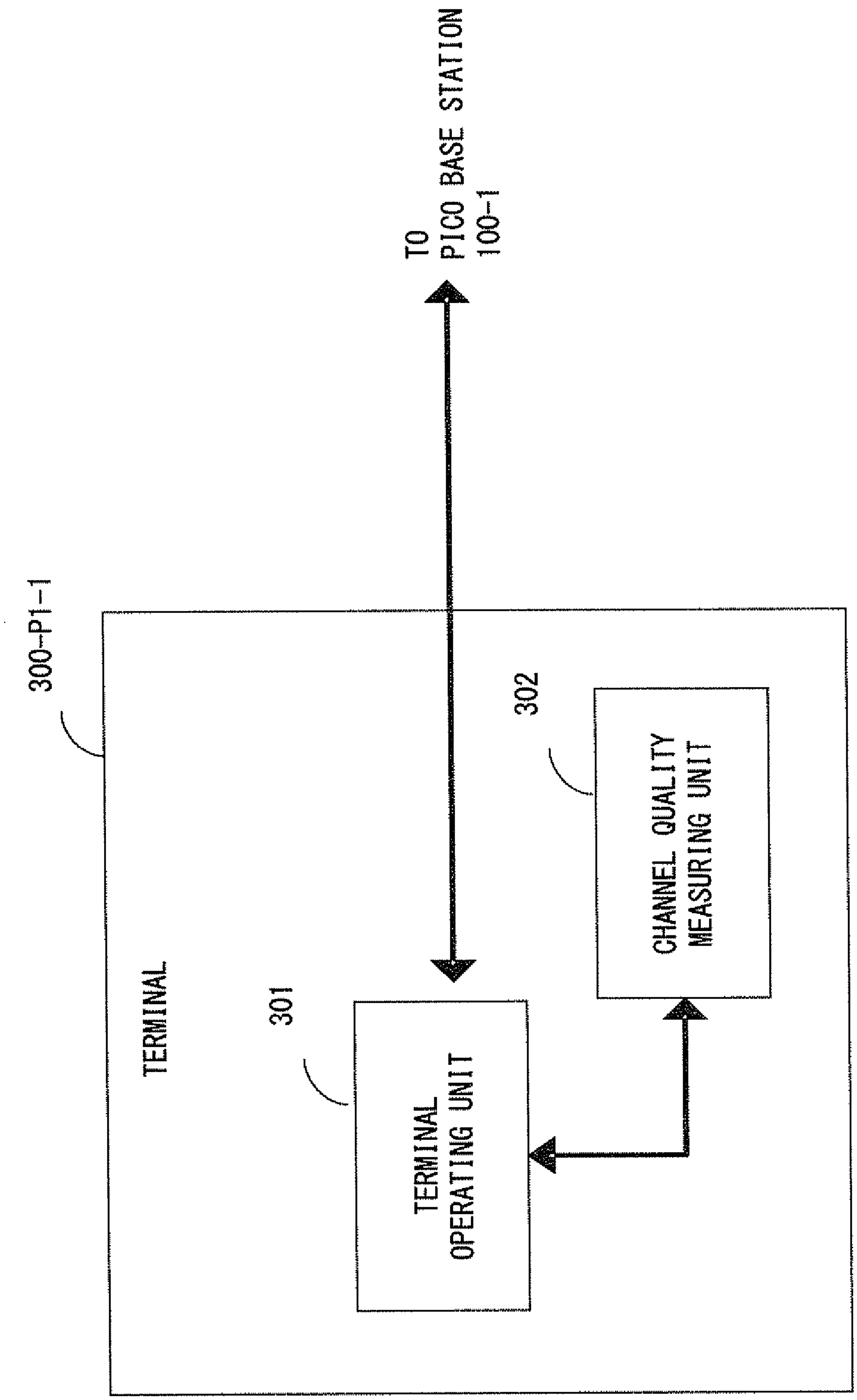

TO
PICO BASE STATION
100-1
300-P1-1
TERMINAL
301
TERMINAL
OPERATING UNIT
302
CHANNEL QUALITY
MEASURING UNIT

Fig. 4

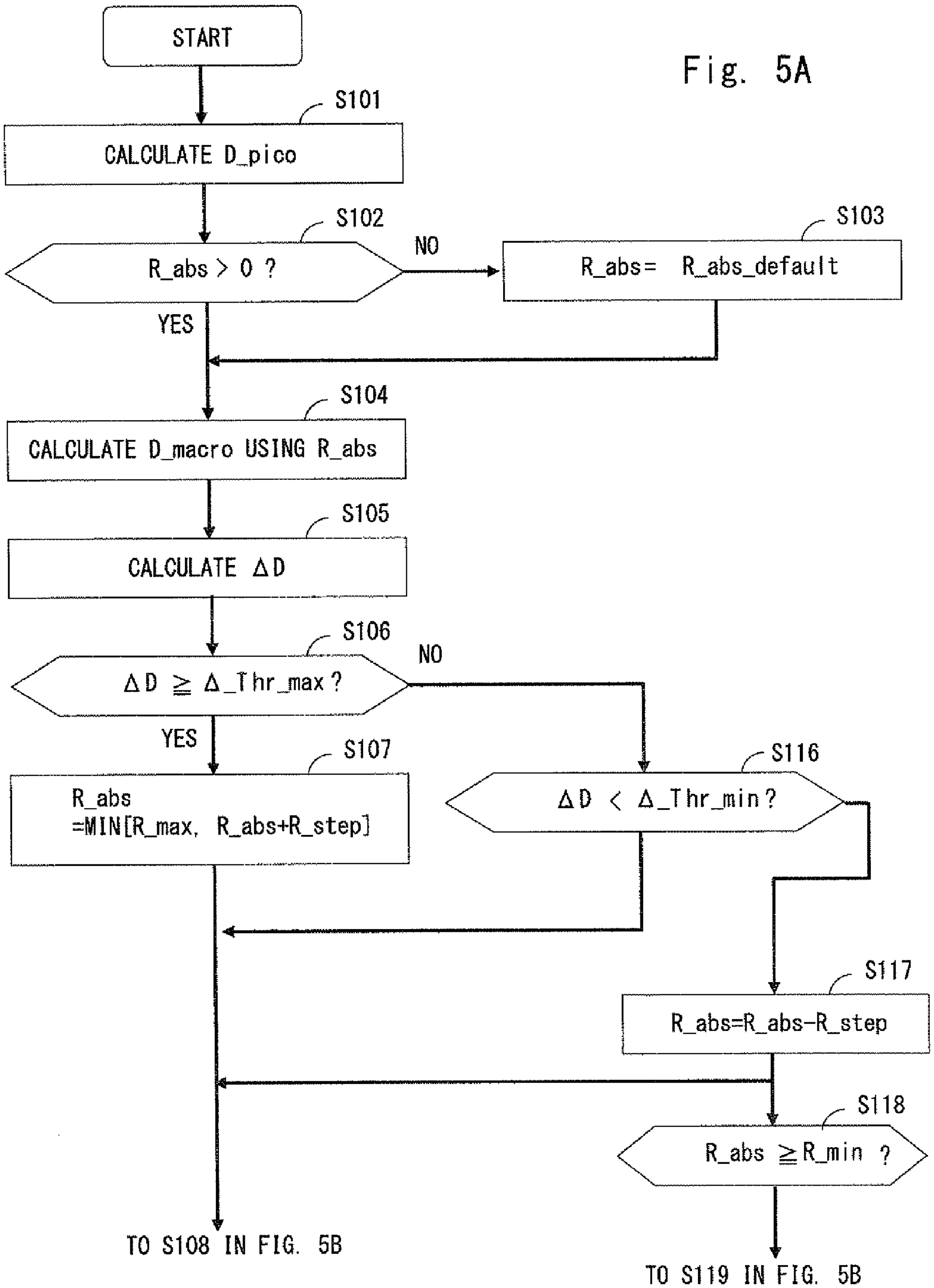
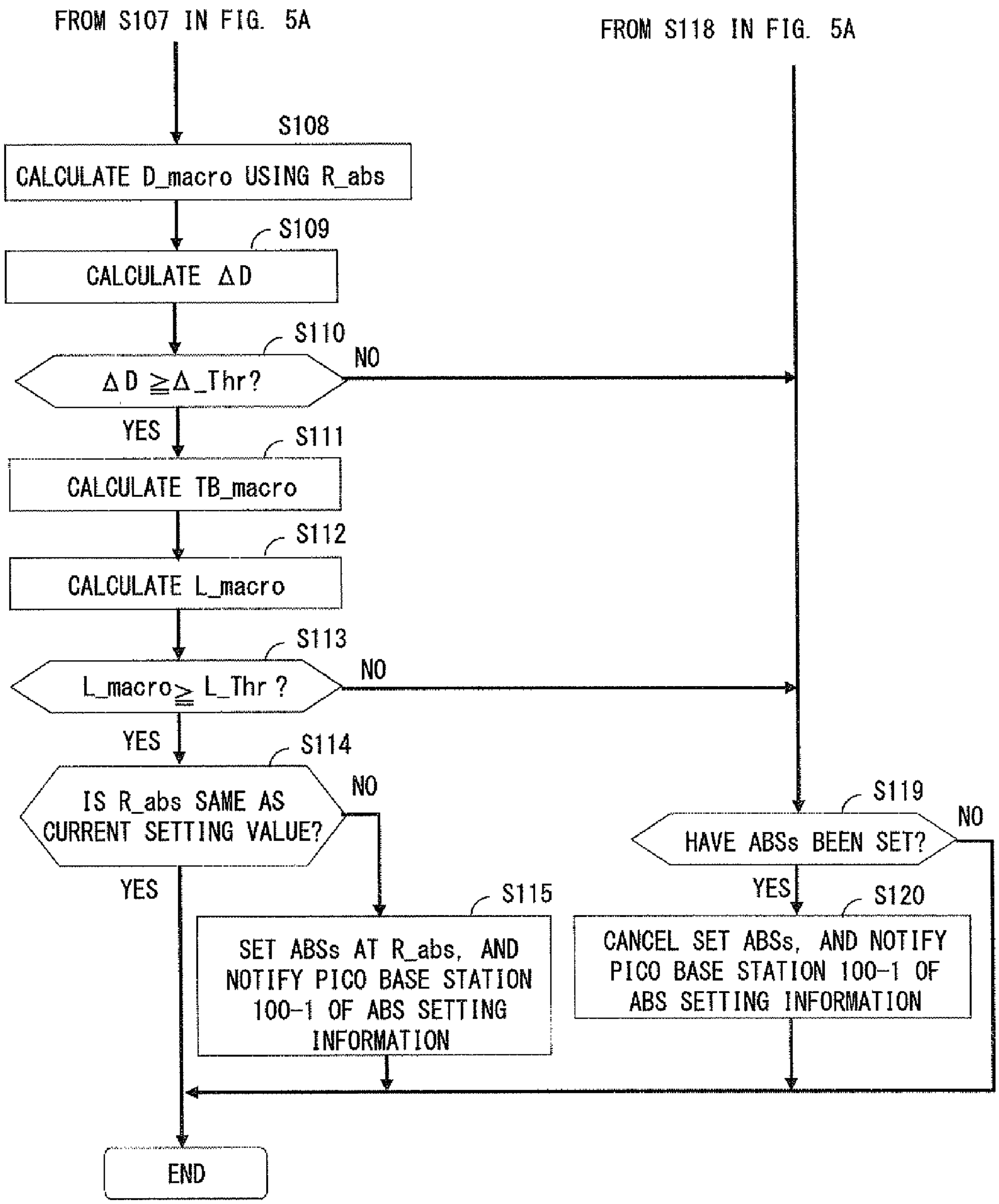

START
S101
CALCULATE D_pico
S102
R_abs > 0 ?
NO
S103
R_abs= R_abs_default
YES
S104
CALCULATE D_macro USING R_abs
S105
CALCULATE ΔD
S106
ΔD ≧ Δ_Thr_max ?
NO
YES
S107
R_abs
=MIN[R_max, R_abs+R_step]
S116
ΔD < Δ_Thr_min ?
S117
R_abs=R_abs-R_step
S118
R_abs ≧R_min ?
TO S108 IN FIG. 5B
TO S119 IN FIG. 5B

Fig. 5A

Fig. 5B



FROM S107 IN FIG. 5A
FROM S118 IN FIG. 5A
S108
CALCULATE D_macro USING R_abs
S109
CALCULATE ΔD
S110
ΔD ≧Δ_Thr?
NO
YES
S111
CALCULATE TB_macro
S112
CALCULATE L_macro
S113
L_macro≧ L_Thr ?
NO
YES
S114
IS R_abs SAME AS CURRENT SETTING VALUE?
NO
YES
S115
SET ABSs AT R_abs, AND NOTIFY PICO BASE STATION 100-1 OF ABS SETTING INFORMATION
S119
HAVE ABSs BEEN SET?
NO
YES
S120
CANCEL SET ABSs, AND NOTIFY PICO BASE STATION 100-1 OF ABS SETTING INFORMATION
END

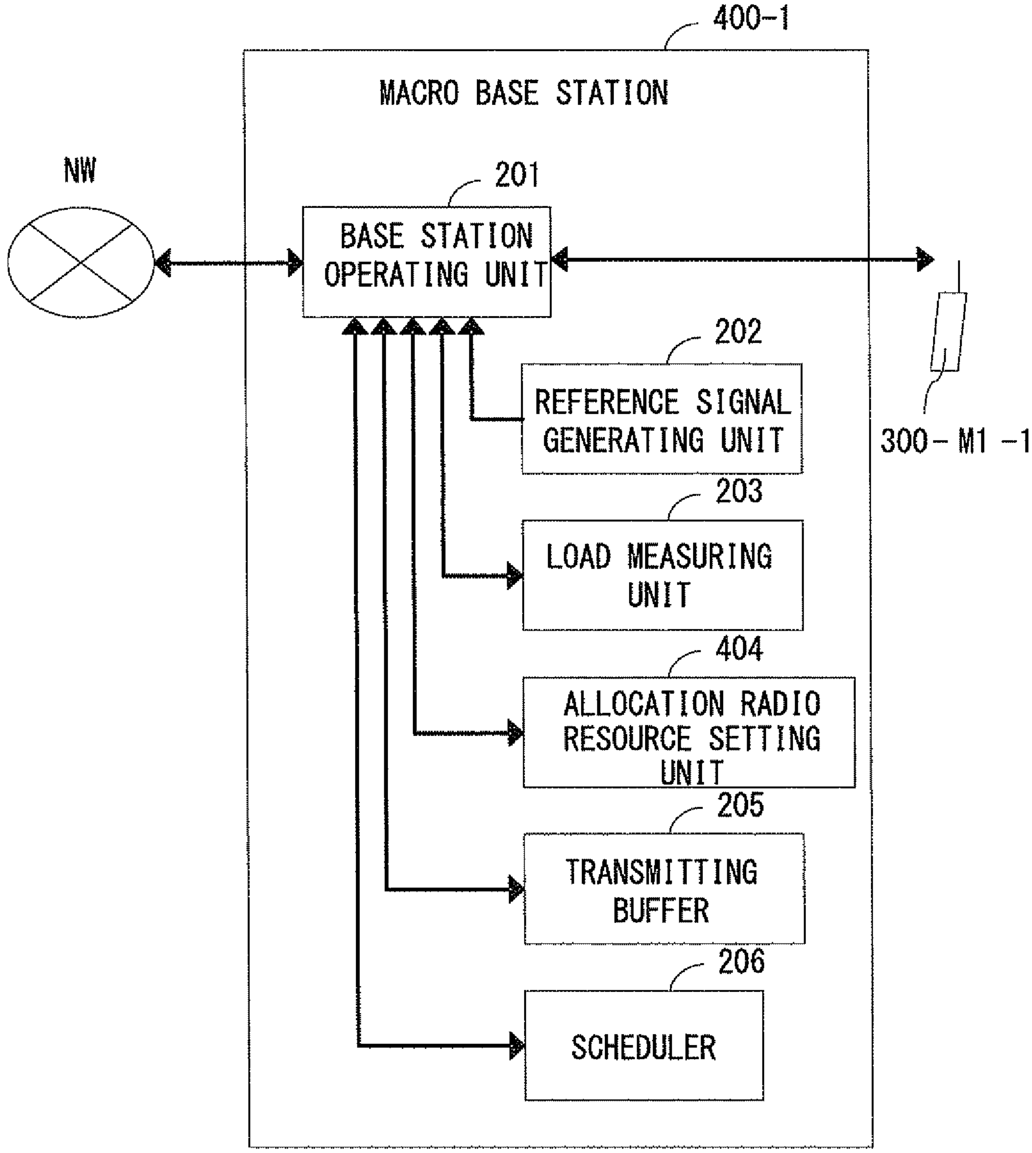
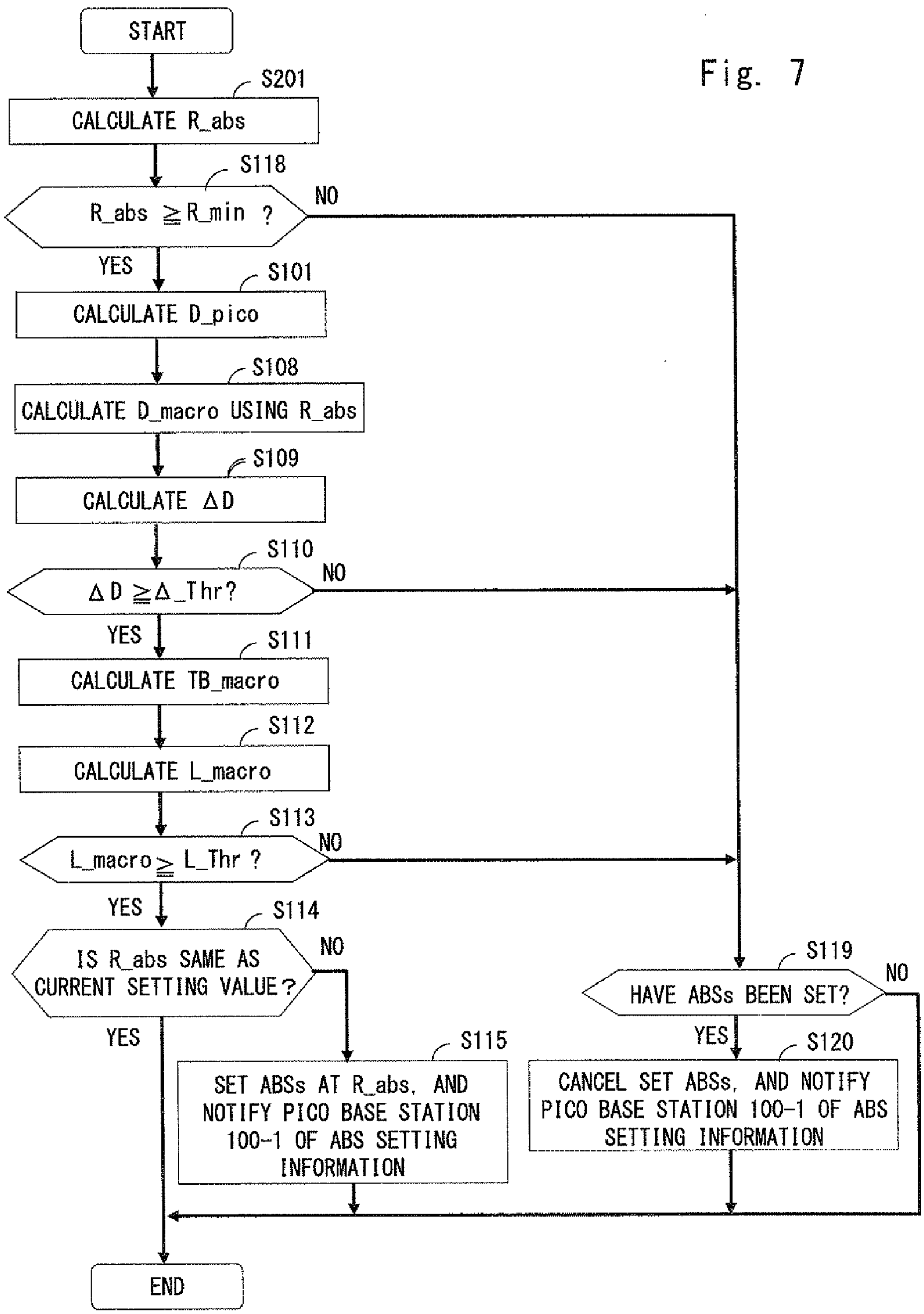

400-1
MACRO BASE STATION
NW
201
BASE STATION OPERATING UNIT
202
REFERENCE SIGNAL GENERATING UNIT
300-M1-1
203
LOAD MEASURING UNIT
404
ALLOCATION RADIO RESOURCE SETTING UNIT
205
TRANSMITTING BUFFER
206
SCHEDULER

Fig. 6

Fig. 7


START
S201
CALCULATE R_abs
S118
R_abs ≧ R_min ?
NO
YES
S101
CALCULATE D_pico
S108
CALCULATE D_macro USING R_abs
S109
CALCULATE ΔD
S110
ΔD ≧ Δ_Thr?
NO
YES
S111
CALCULATE TB_macro
S112
CALCULATE L_macro
S113
L_macro ≧ L_Thr ?
NO
YES
S114
IS R_abs SAME AS CURRENT SETTING VALUE?
NO
YES
S115
SET ABSs AT R_abs, AND NOTIFY PICO BASE STATION 100-1 OF ABS SETTING INFORMATION
S119
HAVE ABSs BEEN SET?
NO
YES
S120
CANCEL SET ABSs, AND NOTIFY PICO BASE STATION 100-1 OF ABS SETTING INFORMATION
END

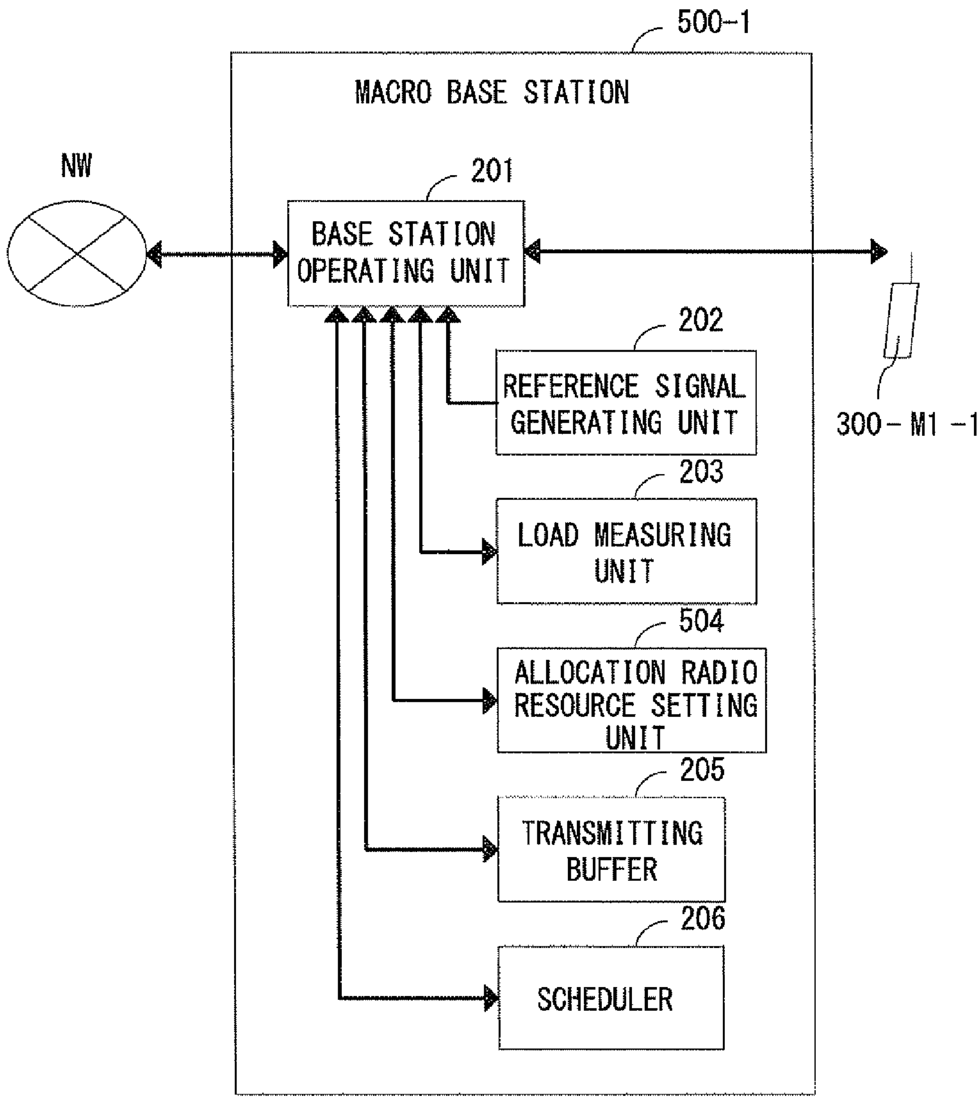

500-1
MACRO BASE STATION
NW
201
BASE STATION OPERATING UNIT
202
REFERENCE SIGNAL GENERATING UNIT
300-M1-1
203
LOAD MEASURING UNIT
504
ALLOCATION RADIO RESOURCE SETTING UNIT
205
TRANSMITTING BUFFER
206
SCHEDULER

Fig. 8

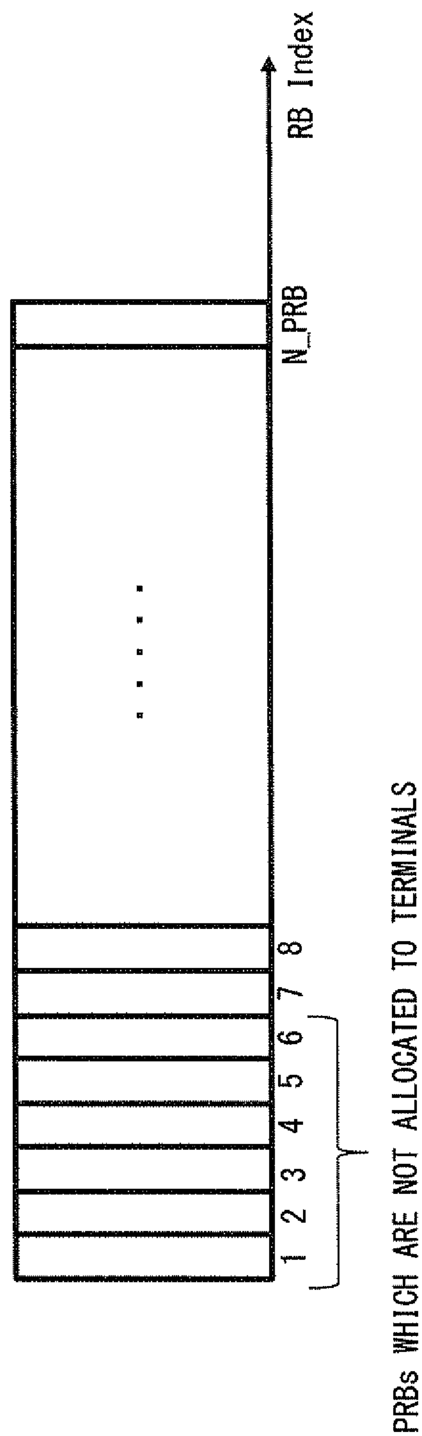

RB Index
N_PRB
1 2 3 4 5 6 7 8
PRBs WHICH ARE NOT ALLOCATED TO TERMINALS

Fig. 9

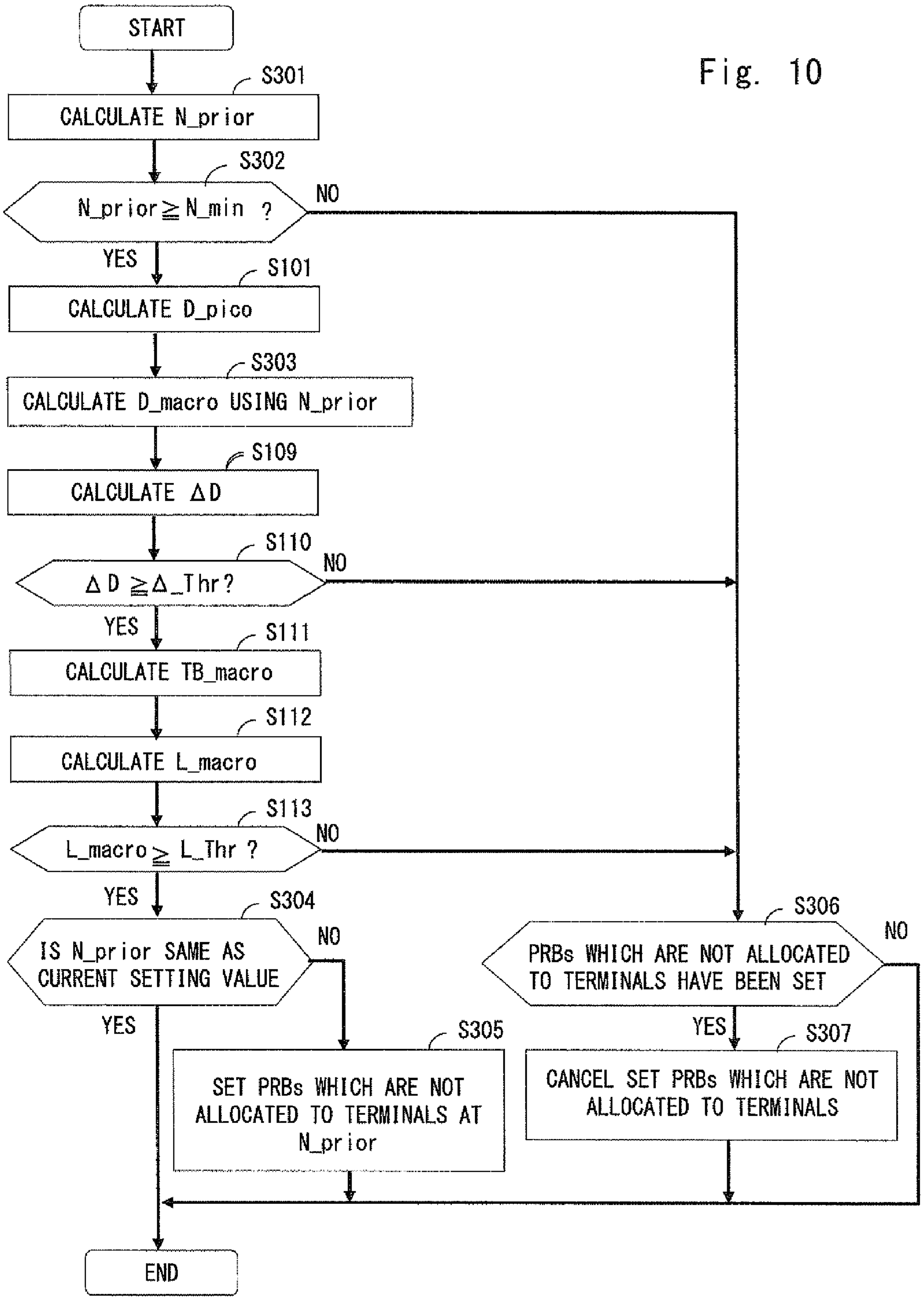
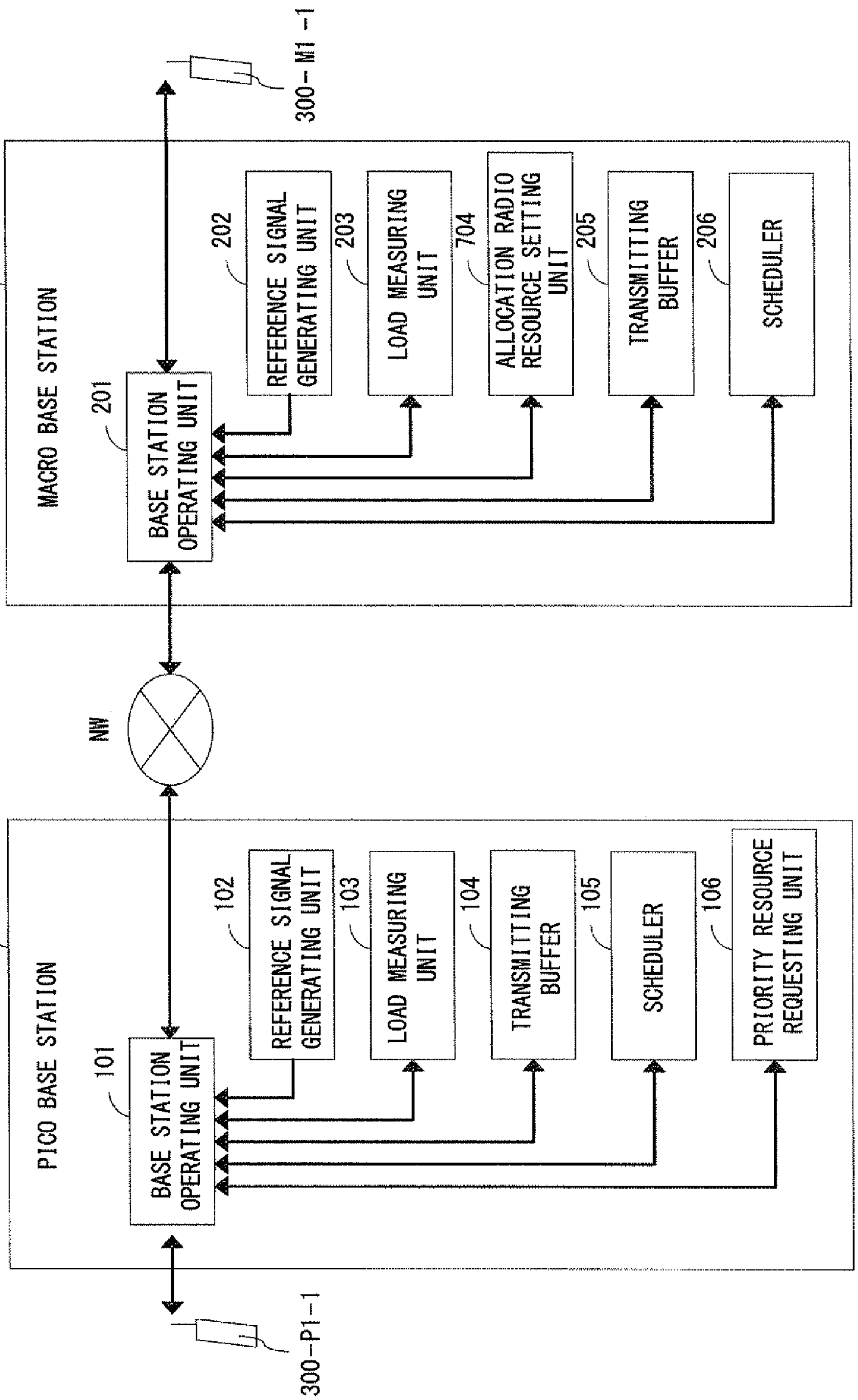

START
S301
CALCULATE N_prior
S302
N_prior≧N_min ?
NO
YES
S101
CALCULATE D_pico
S303
CALCULATE D_macro USING N_prior
S109
CALCULATE ΔD
S110
ΔD ≧Δ_Thr?
NO
YES
S111
CALCULATE TB_macro
S112
CALCULATE L_macro
S113
L_macro≥ L_Thr ?
NO
YES
S304
IS N_prior SAME AS CURRENT SETTING VALUE
NO
YES
S305
SET PRBs WHICH ARE NOT ALLOCATED TO TERMINALS AT N_prior
S306
PRBs WHICH ARE NOT ALLOCATED TO TERMINALS HAVE BEEN SET
NO
YES
S307
CANCEL SET PRBs WHICH ARE NOT ALLOCATED TO TERMINALS
END

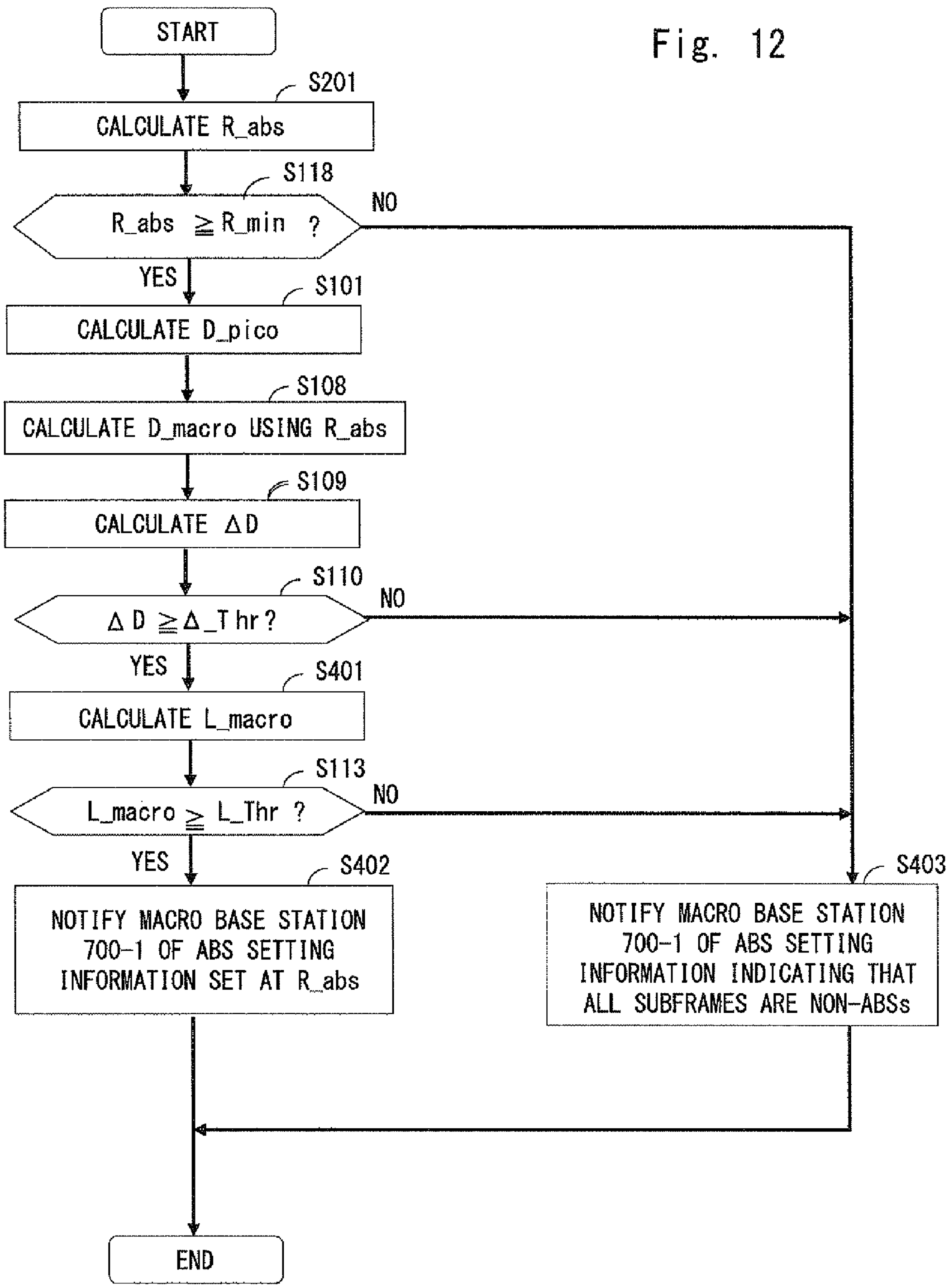
Fig. 10

Fig. 11



300-M1-1
700-1
MACRO BASE STATION
201
BASE STATION OPERATING UNIT
202
REFERENCE SIGNAL GENERATING UNIT
203
LOAD MEASURING UNIT
704
ALLOCATION RADIO RESOURCE SETTING UNIT
205
TRANSMITTING BUFFER
206
SCHEDULER
NW
600-1
PICO BASE STATION
101
BASE STATION OPERATING UNIT
102
REFERENCE SIGNAL GENERATING UNIT
103
LOAD MEASURING UNIT
104
TRANSMITTING BUFFER
105
SCHEDULER
106
PRIORITY RESOURCE REQUESTING UNIT
300-P1-1

Fig. 12


START
S201
CALCULATE R_abs
S118
R_abs ≧ R_min ?
NO
YES
S101
CALCULATE D_pico
S108
CALCULATE D_macro USING R_abs
S109
CALCULATE ΔD
S110
ΔD ≧ Δ_Thr ?
NO
YES
S401
CALCULATE L_macro
S113
L_macro ≧ L_Thr ?
NO
YES
S402
NOTIFY MACRO BASE STATION 700-1 OF ABS SETTING INFORMATION SET AT R_abs
S403
NOTIFY MACRO BASE STATION 700-1 OF ABS SETTING INFORMATION INDICATING THAT ALL SUBFRAMES ARE NON-ABSs
END

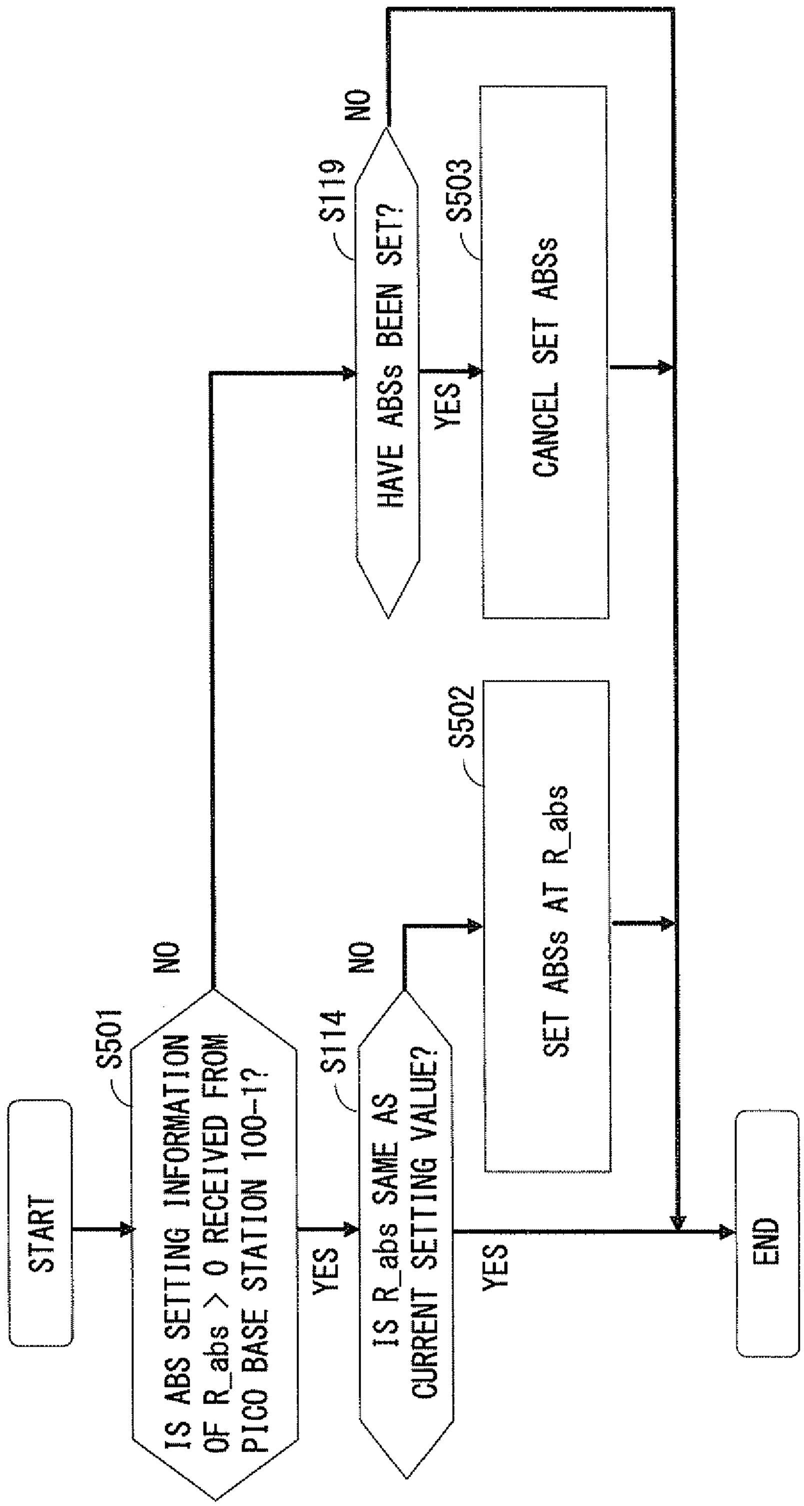

START
S501
IS ABS SETTING INFORMATION OF R_abs > 0 RECEIVED FROM PICO BASE STATION 100-1?
YES
NO
S114
IS R_abs SAME AS CURRENT SETTING VALUE?
YES
NO
S502
SET ABSs AT R_abs
S119
HAVE ABSs BEEN SET?
YES
NO
S503
CANCEL SET ABSs
END

Fig. 13

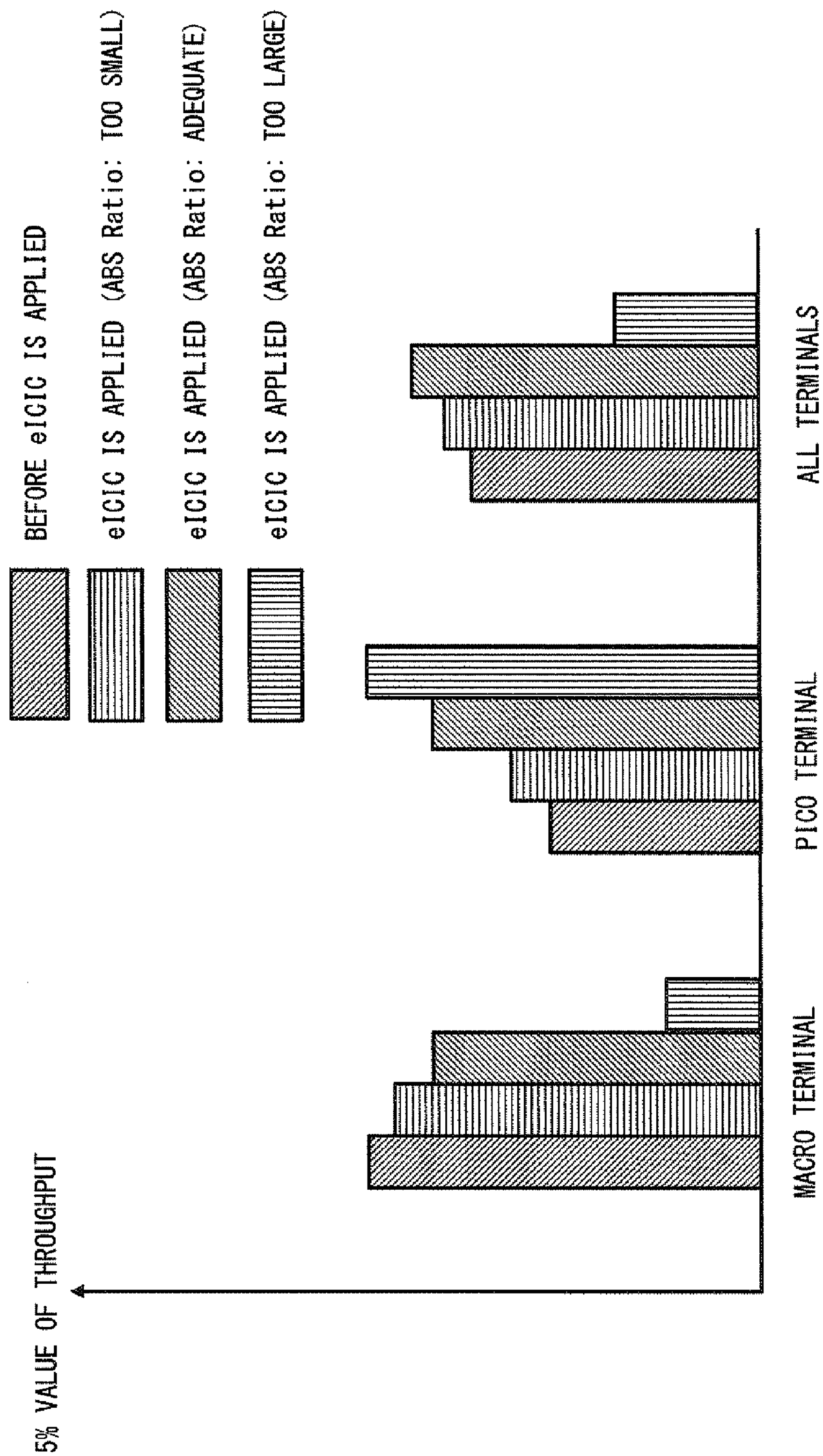

BEFORE eICIC IS APPLIED
eICIC IS APPLIED (ABS Ratio: TOO SMALL)
eICIC IS APPLIED (ABS Ratio: ADEQUATE)
eICIC IS APPLIED (ABS Ratio: TOO LARGE)
5% VALUE OF THROUGHPUT
MACRO TERMINAL
PICO TERMINAL
ALL TERMINALS

Fig. 14

RADIO RESOURCE SETTING METHOD, BASE STATION, RADIO RESOURCE SETTING SYSTEM, AND NON-TRANSITORY COMPUTER READABLE MEDIUM

This application is a National Stage Entry of PCT/JP2013/003932 filed on Jun. 24, 2013, which claims priority from Japanese Patent Application 2012-246962 filed on Nov. 9, 2012, the contents of all of which are incorporated herein by reference, in their entirety.

TECHNICAL FIELD

The present invention relates to an allocation radio resource setting method and, more particularly, relates to an allocation radio resource setting method of suppressing an interference with a neighboring cell.

BACKGROUND ART

A wireless communication system such as LTE (Long Term Evolution) standardized by 3GPP (Third Generation Partnership Project) assumes that a plurality of base stations are located. Each base station used for the wireless communication system communicates with terminals (mobile stations) in a communication area (referred to as a cell below) of each base station. Further, a base station can divide a cell into a plurality of regions when an antenna has directionality. These divided regions are referred to as sector cells. Cells described below include not only normal cells but also sector cells.

According to LTE, the same communication band is usually used between neighboring cells. Hence, a terminal (referred to as an edge terminal below) positioned at a boundary between cells receives a strong interference from a neighboring cell irrespectively of in uplink or in downlink. To deal with such a problem, an interference management technique which is called ICIC (Inter Cell Interference Coordination) and suppresses an interference between neighboring cells by setting a priority band which enables a terminal in a corresponding cell to preferentially perform communication, and, in each cell, limiting allocation radio resources of a priority band of a neighboring cell for a terminal is known. It is conceived that radio resources are limited by excluding a priority band from an allocation target or reducing transmission power of this priority band when the priority band is notified from the neighboring cell.

As a method of setting a priority band, a technique which is called FFR (Fractional Frequency Reuse) and performs fractional frequency reuse such that a priority band does not overlap between cells is known (Non-Patent Literature 1). Further, as a priority band notifying method, LOAD INFORMATION is standardized according to LTE. For example, RNTP (Relative Narrowband TX Power) is defined in downlink of LTE, and HIT (High Interference Indication) is defined in uplink (Non-Patent Literature 2).

Further, as a counter measure for an increase in a traffic amount in recent years, a heterogeneous network in which cells of various sizes are provided by introducing base stations (small cell base stations) of low transmission power in hot spots in addition to conventional macro base stations in a mixed fashion is gaining attention. However, a cell boundary area expands as the number of cells increases, and therefore an inter-cell interference is regarded as a problem.

According to 3GPP Release 10, eICIC (enhanced ICIC) has been studied as an interference management technique, and an ABS (Almost Blank Subframe) has been standardized (Non-Patent Literature 3). eICIC is also referred to as time domain ICIC, and a base station which has set ABSs stops transmission in the ABSs through a control channel (PDCCH: Physical Downlink Control Channel) and a data channel (PDSCH: Physical Downlink Shared Channel) in downlink. A subframe is a radio resource allocation unit time. Thus, the SINR of a terminal in a neighboring cell substantially improves in the ABS, and an increase in throughputs of terminals is expected.

CITATION LIST

Non Patent Literature

NPL 1: Bin Fan et al., "A Dynamic Resource Allocation Scheme Based on Soft Frequency Reuse for OFDMA Systems", IEEE 2007 International Symposium on Microwave, Antenna, Propagation and EMC Technologies for Wireless Communications, pp. 121-125, August 2007

NPL 2: 3GPP TS 36.423 V9.0.0 (2009-09), 3GPP TSG RAN E-UTRAN X2AP, pp. 16-17, p. 29, p. 49, September 2009

NPL 3: 3GPP TS 36.300 V10.6.0 (2011-12), 3GPP TSG RAN E-UTRA and E-UTRAN Overall description Stage 2 (Release 10), p. 116, December 2011

SUMMARY OF INVENTION

Technical Problem

A macro base station which has set ABSs cannot allocate radio resources in the ABSs. Therefore, the throughputs of terminals of the macro base station deteriorate. Therefore, there is a problem that, when an ABS ratio is a fixed value, fairness between throughputs of all terminals of a wireless communication system is substantially lost.

FIG. **14** illustrates a 5% value of throughputs of macro terminals, pico terminals and all terminals before eICIC is applied and when eICIC is applied to three patterns of ABS ratios.

When the ABS ratio with respect to traffic loads of the macro base station and the pico base station before eICIC is applied is too small, throughputs of pico terminals hardly improve. Meanwhile, when the ABS ratio is too large, the throughputs of the terminals of the pico base station improve. However, the throughputs of the terminals of the macro base station substantially deteriorate, and therefore a balance between the throughputs of the terminals of the macro base station and the pico base station is lost. Particularly when throughputs of edge terminals of the macro base station deteriorate, the 5% value of the throughputs of all terminals deteriorates. Therefore, the fairness between the throughputs of the terminals is lost.

To solve the above problem, an object of the present invention is to provide a radio resource setting method, a base station, a radio resource setting system and a program which can improve fairness between throughputs of all terminals.

Solution to Problem

A radio resource setting method according to a first aspect of the present invention is a radio resource setting method for, when there are a first communication area managed by a first base station and a second communication area including at least part of the first communication area and managed by a second base station, setting radio resources that the first and second base stations can use for wireless communication with a terminal, and includes: obtaining loads of the first communication area and the second communication area; calculating a first delay index of the first communication area using the load of the first communication area; calculating using the load of the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set; calculating a ratio of radio resources whose use is limited in the second communication area based on the first delay index and the second delay index; and setting the radio resources whose use is limited in the second communication area using the ratio of the radio resources whose use is limited.

A base station according to a second aspect of the present invention is a base station that performs wireless communication with a terminal in a second communication area that is at least one of a neighboring communication area of a first communication area or a communication area including part of the first communication area, and includes: a load measuring unit that measures a load of the second communication area; and an allocation radio resource setting unit that calculates a first delay index of the first communication area using the load of the first communication area notified from an other base station that manages the first communication area, calculates using the load of the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set, and calculates a ratio of radio resources whose use is limited in the second communication area based on the first delay index and the second delay index.

A radio resource setting system according to a third aspect of the present invention is a radio resource setting system that, when there are a first communication area managed by a first base station and a second communication area including at least part of the first communication area and managed by a second base station, sets radio resources that the first and second base stations can use for wireless communication with a terminal, and is configured to: obtain loads of the first communication area and the second communication area; calculate a first delay index of the first communication area using the load of the first communication area; calculate using the load of the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set; calculate a ratio of the radio resources whose use is limited in the second communication area based on the first delay index and the second delay index; and set the radio resources whose use is limited in the second communication area using the ratio of the radio resources whose use is limited.

A program according to a fourth aspect of the present invention is a program that is executed by a computer of a base station that performs wireless communication with a terminal in a second communication area that is at least one of a neighboring communication area of a first communication area or a communication area including part of the first communication area, and causes the computer to execute: obtaining a load of the second communication area; calculating a first delay index of the first communication area using a load of the first communication area notified from an other base station that manages the first communication area; calculating using the load of the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set; and calculating a ratio of the radio resources whose use is limited in the second communication area based on the first delay index and the second delay index.

Advantageous Effects of Invention

The present invention can provide a radio resource setting method, a base station, a radio resource setting system and a program which can improve fairness between throughputs of all terminals.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a configuration diagram of a wireless communication system according to a first embodiment.

FIG. **2** is a configuration diagram of a pico base station and a macro base station according to the first embodiment.

FIG. **3** is a view illustrating a method where the macro base station sets radio resources whose use is limited according to the first embodiment.

FIG. **4** is a configuration diagram of a terminal according to the first embodiment.

FIG. **5**A is a view illustrating a method where the macro base station calculates a ratio of radio resources whose use is limited according to the first embodiment.

FIG. **5**B is a view illustrating a method where the macro base station calculates a ratio of radio resources whose use is limited according to the first embodiment.

FIG. **6** is a configuration diagram of a macro base station according to a second embodiment.

FIG. **7** is a view illustrating a method where the macro base station calculates a ratio of radio resources whose use is limited according to the second embodiment.

FIG. **8** is a configuration diagram of a macro base station according to a third embodiment.

FIG. **9** is a view illustrating a method where the macro base station sets radio resources whose use is limited according to the third embodiment.

FIG. **10** is a view illustrating a method where the macro base station calculates a ratio of radio resources whose use is limited according to the third embodiment.

FIG. **11** is a configuration diagram of a pico base station and a macro base station according to a fourth embodiment.

FIG. **12** is a view illustrating a method where the pico base station requests radio resources whose use is limited according to the fourth embodiment.

FIG. **13** is a view illustrating a method where the macro base station sets radio resources whose use is limited according to the fourth embodiment.

FIG. **14** is a view illustrating a problem caused when eICIC is applied.

DESCRIPTION OF EMBODIMENTS

First Embodiment

ABS Ratio is Updated by Predetermined Step According to Load

Next, an embodiment of the present invention will be described in detail with reference to the drawings.

[Explanation of Configuration]

FIG. **1** illustrates a configuration of a wireless communication system **10** according to the first embodiment of the present invention. The present invention is applied to downlink of LTE in the wireless communication system **10**. The wireless communication system **10** includes pico base stations **100-1** and **100-2**, macro base stations **200-1** and **200-2**, and a plurality of terminals **300-P1-1**, **300-P1-2**, **300-P2-1**, **300-P2-2**, **300-M1-1**, **300-M1-2**, **300-M2-1** and **300-M2-2**. An example where the wireless communication system **10** includes two macro base stations and two pico base stations will be described with reference to FIG. **1**. However, the wireless communication system **10** may include two or more base stations. Further, the wireless system communication **10** may include a greater number of terminals than the number of terminals illustrated in FIG. **1**. M represents an initial letter of Macro, and P represents an initial letter of Pico. In this regard, a terminal **300-P1-X** is connected to the pico base station **100-1**. Further, a terminal **300-M1-Y** is connected to the macro base station **200-1**. X and Y represent arbitrary indices for allowing each base station to identify a terminal.

Common matters between respective pico base stations and between respective macro base stations will be described below to read "a pico base station **100** . . . " and "a macro base station **200** . . . ", respectively. Similarly, common matters between respective terminals connected to a pico base station and between respective terminals connected to a macro base station will be described to read "a pico terminal **300-P** . . . " and "a macro terminal **300-M** . . . ", respectively. Further, common matters irrespectively of base stations to connect to will be described to read "a terminal **300** . . . ".

The pico base stations **100-1** and **100-2** and the macro base stations **200-1** and **200-2** can communicate with each other through a communication line NW. Further, each pico base station **100** and each macro base station **200** each can manage a plurality of communication areas (cells). In the present embodiment, an example where each pico base station **100** and each macro base station **200** each manage one communication area will be described in the present embodiment.

The pico base station **100** is a low transmission power base station, and includes a narrower communication area than that of the macro base station **200**. The communication area of each pico base station **100** is a communication area at least part of which is included in the communication area of each macro base station **200**.

Each pico base station **100** performs wireless communication with the terminal **300-P** in the communication area managed by the pico base station **100**. Each pico base station **100** can simultaneously execute wireless communication with a plurality of terminals **300-P**, respectively.

Each macro base station **200** performs wireless communication with the terminal **300-M** in a communication area formed by subtracting the communication area managed by the pico base station **100** from the communication area managed by the macro base station **200**. Each macro base station **200** can simultaneously execute wireless communication with a plurality of terminals **300-M**, respectively.

Each pico base station **100** and each macro base station **200** each include an information processing apparatus which is not illustrated. The information processing apparatus includes a central processing unit (CPU) and a storage device (a memory and a hard disk drive (HDD)) which are not illustrated. Each pico base station **100** and each macro base station **200** are each configured to realize functions described below when the CPU executes a program stored in the storage device.

Each terminal **300** is a mobile telephone terminal. In addition, each terminal **300** may be a personal computer, a PHS (Personal Handyphone System) terminal, a PDA (Personal Data Assistance or Personal Digital Assistant), a smartphone, a car navigation terminal, a game terminal or the like.

Each terminal **300** includes a CPU, a storage device (memory), an input device (key buttons and a microphone) and an output device (a display and a speaker). Each terminal **300** is configured to realize functions described below when the CPU executes a program stored in the storage device.

FIG. **2** is a block diagram illustrating the functions of each pico base station **100** and each macro base station **200** in the wireless communication system **10** configured as described above. The functions will be described using the pico base station **100-1** as a pico base station and the macro base station **200-1** as a macro base station. Although not illustrated in FIG. **2**, functions of the pico base station **100-2** are the same as the functions of the pico base station **100-1**. Similarly, functions of the macro base station **200-2** are the same as the functions of the macro base station **200-1**.

The pico base station **100-1** includes a base station operating unit **101**, a reference signal generating unit **102**, a load measuring unit **103**, a transmitting buffer **104** and a scheduler **105**.

The base station operating unit **101** has a function of transmitting and receiving radio signals to and from each terminal **300-P1** which is being connected with the pico base station **100-1**, a function of notifying each terminal **300-P1** of an allocation band used to transmit and receive radio signals, scheduling information such as an MCS (Modulation and Coding Scheme) Index and setting information of transmission power, and a function of notifying each terminal **300-P1** of a report timing of CSI (Channel State Information) such as a CQI (Channel Quarity Indicator). Further, the base station operating unit **101** includes a surrounding base station list in which information used to identify the macro base station **200-1** and other surrounding macro base stations **200-*k*** (k≠1) is described, and has a function of communicating with surrounding base stations through the communication line NW, and a function of holding ABS setting information (ABS Status) notified from the surrounding base stations. However, these configurations and operations are known and therefore will not be described.

The reference signal generating unit **102** has a function of generating a reference signal which the terminal **300** uses to measure channel quality with respect to the pico base station **100-1**. The reference signal generating unit **102** transmits a generated signal to each terminal **300** through the base station operating unit **101**.

The load measuring unit **103** has a function of measuring a load of the pico base station **100-2** per predetermined cycle, and notifying the surrounding base stations including at least the macro base station **200-1** of information of the measured load through the base station operating unit **101**. In the present embodiment, the load is a PRB (Physical Resource Block) use ratio. The PRB is a radio band allocation unit.

The transmitting buffer **104** has a function of accumulating transmission data which arrives through the communication line NW and is addressed to each terminal **300-P**, and information which is used to transmit the transmission data.

The scheduler **105** has a function of determining transmission power, a frequency band and a MCS Index allocated per terminal **300-P**, based on a size of transmission data accumulated in the transmitting buffer **104** and addressed to each terminal **300-P**, the ABS setting information of the macro base station **200-1** held in the base station operating unit **101** and the CSI reported from each terminal **300-P**, and transmitting data through the base station operating unit **101**. In the present embodiment, when a current subframe is an ABS, the scheduler **105** uses a CSI of the ABS reported from each terminal **300**-P. Further, when the current subframe is not an ABS (referred to as a Non-ABS below), the scheduler **105** uses a CSI of a subframe of the Non-ABS reported from each terminal **300**-P.

The macro base station **200-1** includes a base station operating unit **201**, a reference signal generating unit **202**, a load measuring unit **203**, an allocation radio resource setting unit **204**, a transmitting buffer **205** and a scheduler **206**.

The base station operating unit **201** has a function of transmitting and receiving radio signals to and from each terminal **300**-M**1** which is being connected with the macro base station **200-1**, a function of determining scheduling information such as an allocation band and a MCS Index used to transmit and receive the radio signals, and setting information of transmission power per terminal **300**-M**1**, and notifying each terminal **300**-M**1** of the scheduling information and the setting information, and a function of notifying each terminal **300**-M**1** of a report timing of a CSI. Further, the base station operating unit **201** includes a surrounding base station list in which information used to identify the pico base station **100-1**, surrounding macro base stations **200**-*k* (k≠1) and a pico base station **100**-*k* located in a communication area of each surrounding macro base station **200**-*k* is described, and has a function of communicating with surrounding base stations through the communication line NW. However, these configurations and operations are known and therefore will not be described.

The reference signal generating unit **202** has the same functions as those of the reference signal generating unit **102** of the pico base station **100-1**, and therefore will not be described.

The load measuring unit **203** has a function of measuring a load of the macro base station **200-1** per predetermined cycle, and notifying the surrounding base stations including at least the pico base station **100-1** of information of the measured load through the base station operating unit **201**. The allocation radio resource setting unit **204** uses the load measured by the load measuring unit **203**, through the base station operating unit **201**.

The allocation radio resource setting unit **204** has a function of updating a ratio of radio resources whose use is limited using load information notified from the pico base station **100-1**, the load of the macro base station **200-1** measured by the load measuring unit **203** and current ABS setting information of the macro base station **200-1** held in the base station operating unit **201**. Further, the allocation radio resource setting unit **204** has a function of calculating a delay index for determining a delay time of a terminal of the pico base station **100-1** and a delay index indicating a delay time of the macro base station **200-1** in case where radio resources whose use is limited have been set, respectively, using the updated ratio of the resources whose use is limited, the load information notified from the pico base station **100-1** and the load of the macro base station **200-1** measured by the load measuring unit **203**.

Furthermore, the allocation radio resource setting unit **204** has a function of calculating a load index of the macro base station **200-1** using the load of the macro base station **200-1** measured by the load measuring unit **203** and a size (referred to a buffer size below) of transmission data which is being buffered in the transmitting buffer **205**. Still further, the allocation radio resource setting unit **204** has a function of determining whether or not to set radio resources whose use is limited by the macro base station **100-1** using the calculated delay index of the pico base station **100-1** and the calculated delay index and load index of the macro base station **200-1**, and notifying the pico base station **100-1** of a determination result referring to a surrounding base station list managed by the base station operating unit **201**.

In the present embodiment, the radio resources whose use is limited are subframes of the macro base station **200-1**, and subframes whose use is limited are ABSs. In the present embodiment, as illustrated in FIG. **3**, ABSs are set at a cycle of eight subframes. Hence, an ABS ratio (R_abs) is calculated using subframes set in 1/8 units. Further, a numerical value in each subframe in FIG. **3** represents an ABS setting order. As illustrated in FIG. **3**, when R_abs takes 2/8, the allocation radio resource setting unit **204** sets head two subframes as ABSs. Further, the allocation radio resource setting unit **204** does not set an ABS when radio resources whose use is limited are not set. Furthermore, the allocation radio resource setting unit **204** uses ABS setting information to notify a determination result. In the ABS setting information, ABSs set by the macro base station **200-1** and an ABS ratio with respect to all subframes are described. As disclosed in Non-Patent Literature 4 (3GPP TS 36.423 V10.3.0 (2011-09), 3GPP TSG RAN E-UTRAN X2AP, p. 72, September 2011), in the ABS setting information, ABS patterns indicating that an ABS is 1 and a Non-ABS is 0 are described.

The transmitting buffer **205** has the same function as that of the transmitting buffer **105** of the pico base station **100-1** and therefore will not be described.

The scheduler **206** has a function of determining transmission power, a frequency band and a MCS Index allocated per terminal **300**-P, based on a size of transmission data accumulated in the transmitting buffer **205** and addressed to each terminal **300**-P, the ABS setting information set by the allocation radio resource setting unit **204** and the CSI reported from each terminal **300**-P, and transmitting data through the base station operating unit **101**.

FIG. **4** is a block diagram illustrating a function of the terminal **300**-P**1-1** in the wireless communication system **10**. Although not illustrated in FIG. **4**, the functions of the terminal **300**-P**1-1** are the same as functions of the terminal **300**-P**1-2**, the terminal **300**-P**2-1**, the terminal **300**-P**2-2**, the terminal **300**-M**1-1** and the terminal **300**-M**1-2**. The terminal **300**-P**1-1** includes a terminal operating unit **301** and a channel quality measuring unit **302**.

The terminal operating unit **301** has a function of transmitting and receiving radio signals to and from the pico base station **100-1** which is being connected with the terminal **300**-P**1-1** (communication link is established). The function of the terminal operating unit **301** is a known function of a general wireless communication system, and therefore will not be described.

The channel quality measuring unit **302** has a function of measuring channel quality with respect to a reference signal, and transmitting information of the measured channel quality to the pico base station **100-1**. In the present embodiment, the channel quality is a CQI calculated from RSRP (Reference Signal Received Power) and a SINR (Signal To Interference and Noise Ratio) with respect to the reference signal of the pico base station **100-1**. The RSRP is reception power of the reference signal, and is used as a reference value of cell selection or handover in the present embodiment.

[Explanation of Operation]

Next, an operation of the above wireless communication system **10** will be described with reference to FIGS. **5**A and **5**B. FIGS. **5**A and **5**B illustrate operation procedures in which the allocation radio resource setting unit **204** of the macro base station **200-1** sets radio resources whose use is limited by the macro base station **200-1**. The allocation radio resource setting unit **204** executes the operations illustrated in FIGS. **5**A and **5**B at each cycle at which the load measuring unit **203** measures a PRB use ratio.

First, the allocation radio resource setting unit **204** calculates a delay index of the pico base station **100-1**. The delay time and the PRB use ratio are correlated, and therefore the allocation radio resource setting unit **204** calculates a delay index D_pico of the pico base station **100-1** according to equation 1 (step S**101**). In equation 1, U_pico represents the PRB use ratio of the pico base station **100-1** notified from the pico base station **100-1**.

[Mathematical 1]

$$D\_pico = U\_pico \quad (1)$$

Next, the allocation radio resource setting unit **204** determines whether or not a current ABS ratio R_abs of the macro base station **200-1** is larger than 0 (step S**102**).

When R_abs is larger than 0 (Step S**102**, Yes), the allocation radio resource setting unit **204** calculates a delay index D_macro of the macro base station **200-1** which has set radio resources whose use is limited, according to equation 2 (step S**104**). In equation 2, U_macro represents the PRB use ratio of the macro base station **200-1** measured by the load measuring unit **203**, and w represents a weight coefficient. It is assumed that, in case where the macro base station **200-1** has set radio resources whose use is limited, a delay time becomes longer as R_abs becomes larger. In the present embodiment, the weight coefficient w is 1. However, the weight coefficient w may be set according to the number of terminals simultaneously connected with the macro base station **200-1** or channel quality of a terminal. It is assumed that, when, for example, the number of simultaneously connected terminals before ABSs are set is great, the weight coefficient is set to a value larger than 1, and a delay index further increases. This is because a transmission rate of a terminal lowers when ABSs are set, and therefore a window size of a TCP hardly expands and a transmission delay rapidly increases. Further, it is assumed that, when, for example, ABSs are set and improvement of channel quality in Non-ABSs can be expected, the weight coefficient is set to a value smaller than 1, and a delay index does not increase so much. This is because channel quality in the Non-ABSs improves, and therefore transmission rates of transmission subframes improve.

[Mathematical 2]

$$D\_macro = w \times \{U\_macro/(1-R\_abs)\} \quad (2)$$

Meanwhile, when R_abs is 0 (step S**102**, No), the allocation radio resource setting unit **204** sets R_abs to R_abs_ini (step S**103**), and moves to step S**104**. R_abs_ini is an initial value of an ABS ratio, and the initial value is a minimum value R_min of the ABS ratio and is set to 1/8 in the present embodiment.

Next, the allocation radio resource setting unit **204** calculates a relative delay index ΔD of the pico base station **100-1** according to equation 3 (step S**105**).

[Mathematical 3]

$$\Delta D = D\_pico - D\_\_ \quad (3)$$

Next, the allocation radio resource setting unit **204** determines whether or not the calculated relative delay index ΔD is larger than a required value Δ_Thr_max (step S**106**).

When the relative delay index ΔD is larger than the required value Δ_Thr_max (step S**106**, Yes), the allocation radio resource setting unit **204** determines that, in case of the current ABS ratio R_abs, a delay time of the pico terminal **300**-P**1** with respect to the delay time of the macro terminal **300**-M**1** in case where the macro base station **200-1** has set radio resources whose use is limited is too large, and updates the ABS ratio R_abs according to equation 4 (step S**107**). In equation 4, R_step is an update step size of the ABS ratio R_abs, and takes 1/8 in the present embodiment. Further, R_max represents an upper limit value of the settable ABS ratio, and takes 7/8 in the present embodiment.

[Mathematical 4]

$$R\_abs = \mathrm{MIN}[R\_max, R\_abs + R\_step] \quad (4)$$

Next, the allocation radio resource setting unit **204** recalculates the delay index D_macro of the macro base station **200-1** which has set the radio resources whose use is limited using the updated ABS ratio R_abs, according to equation 2 (step S**108**), and recalculates the relative delay index ΔD of the pico base station **100-1**, too, according to equation 3 (step S**109**).

Next, the allocation radio resource setting unit **204** determines whether or not the recalculated relative delay index ΔD is a required value Δ_Thr or more (step S**110**).

When the recalculated relative delay index ΔD is the required value Δ_Thr or more (step S**110**, Yes), the allocation radio resource setting unit **204** determines that, in case of the updated ABS ratio R_abs, an increase in a delay time of the terminal **300**-M**1** in case where the macro base station **200-1** has set the radio resources whose use is limited is not great, and calculates the number of transmitted bits TB (Transmitted Bits)_macro per RB of the macro base station **200-1** which is required to calculate a load index L_macro of the macro base station **200-1**, according to equation 5 (step S**111**). In equation 5, U_macro is a PRB use ratio of the macro base station **200-1** measured by the load measuring unit **203**. BS_present is a buffer size which is being buffered in the transmitting buffer **205** in a current subframe. BS_past is a buffer size which has been buffered in a subframe a predetermined time T_subframe before from a current subframe. ΔS is a data size which has arrived at the transmitting buffer **205** in this predetermined time T_subframe.

On a right side of equation 5, a numerator represents a total size of data whose transmission has been completed by the macro base station **200-1** in the predetermined time T_subframe, and a denominator represents a total number of PRBs which the macro base station **200-1** has used to transmit data in the predetermined time T_subframe. N_PRB represents the number of allocatable PRBs per subframe, and T_subframe represents a notification cycle of a PRB use ratio.

[Mathematical 5]

$$TB\_macro[\text{bits/Subframe}] = (BS\_past + \Delta S - BS\_present)/(U\_macro \times N\_PRB \times T\_subframe) \quad (5)$$

Next, the allocation radio resource setting unit **204** calculates the load index L_macro of the macro base station **200-1** using calculated TB_macro according to equation 6A (step S**112**). According to equation 6A, it is possible to calculate as a load index of the macro base station **200-1** an estimated PRB use ratio which is a ratio of a total number of PRBs required until transmission of data which is being buffered in a transmitting buffer is finished, with respect to the total number of PRBs which can be used until the predetermined time T_subframe passes from a current time.

[Mathematical 6]

$$L\_macro=MIN[1.0,(BS\_present/TB\_macro)/(N\_PRB\times T\_subframe)] \quad (6A)$$

Next, the allocation radio resource setting unit **204** determines whether or not the calculated load index L_macro of the macro base station **200-1** is a threshold L_Thr or more (step S**113**).

When the calculated load index L_macro is the threshold L_Thr or more (step S**113**, Yes), the allocation radio resource setting unit **204** determines that a transmission probability of the macro base station **200-1** is high, and a probability that a pico terminal **300**-P1 receives an interference from the macro base station **200-1** is high, too, and determines whether or not the updated ABS ratio is the same as a current setting value (step S**114**).

When the updated ABS ratio is the same as the current setting value (step S**114**, Yes), the allocation radio resource setting unit **204** finishes the processing in FIG. **5**. Meanwhile, when the updated ABS ratio is different from the current setting value (step S**114**, No), the allocation radio resource setting unit **204** sets ABSs at the updated ABS ratio, and notifies the pico base station **100-1** of setting information of the set ABSs. Subsequently, the allocation radio resource setting unit **204** finishes the processing in FIG. **5**.

Meanwhile, when the relative delay index ΔD is the required value Δ_Thr_max or less (step S**106**, No), the allocation radio resource setting unit **204** determines whether or not the relative delay index ΔD is less than a required value Δ_Thr_min (<Δ_Thr_max) (step S**116**). When the relative delay index ΔD is the required value Δ_Thr_min or more (step S**116**, No), the allocation radio resource setting unit **204** moves to step S**108** without changing the ABS ratio R_abs. Meanwhile, when the relative delay index ΔD is less than the required value Δ_Thr_min (step S**116**, Yes), the allocation radio resource setting unit **204** determines that, in case of the current ABS ratio R_abs, an increase in a delay time of the terminal **300**-M1 in case where the macro base station **200-1** has set the radio resources whose use is limited is great, and updates the ABS ratio R_abs according to equation 7 (step S**117**).

[Mathematical 7]

$$R\_abs=R\_abs-R\_step \quad (7)$$

Subsequently, the allocation radio resource setting unit **204** determines whether or not the updated ABS ratio R_abs is the minimum value R_min or more (step S**118**).

When the updated ABS ratio R_abs is the minimum value R_min or more (step S**118**, Yes), the allocation radio resource setting unit **204** moves to step S**108**. Meanwhile, when the updated ABS ratio R_abs is less than the minimum value R_min (step S**118**, No), the allocation radio resource setting unit **204** determines that the macro base station **200-1** cannot set ABSs, and determines whether or not the macro base station **200-1** has already set the ABSs (step S**119**). In case where the macro base station **200-1** has set the ABSs (step S**119**, Yes), the allocation radio resource setting unit **204** cancels the set ABSs, and notifies the pico base station **100-1** of the ABS setting information (step S**120**). Subsequently, the allocation radio resource setting unit **204** finishes the processing in FIG. **6**. Meanwhile, in case where the macro base station **200-1** has not set the ABSs (step S**119**, No), the allocation radio resource setting unit **204** finishes the processing in FIG. **5**.

Further, when the recalculated relative delay index ΔD is less than the required value Δ_Thr (step S**110**, No), the allocation radio resource setting unit **204** determines that, in case of the updated ABS ratio R_abs, an increase in the delay time of the terminal **300**-M1 in case where the macro base station **200-1** has set radio resources whose use is limited is great, and moves to step S**119**.

Furthermore, when the load index L_macro of the macro base station **200-1** is less than the threshold L_Thr (step S**113**, No), the allocation radio resource setting unit **204** determines that a transmission probability of the macro base station **200-1** is low, and a probability that a pico terminal **300**-P1 receives an interference from the macro base station **200-1** is low, too, and moves to step S**119**.

As described above, according to the pico base station **100-1** and the macro base station **200-1** according to the first embodiment of the present invention, when a load of the macro base station **200-1** is great, the macro base station **200-1** sets the radio resources whose use is limited such that a relative delay index of the pico base station **100-1** settles in a predetermined range. Consequently, it is possible to avoid deterioration of a 5% value of throughputs of all terminals due to deterioration of a throughput of the macro terminal **300**-M, and improve fairness between throughputs of all communication terminals **300** including terminals of the macro base station **200** and the pico base station **100**.

The present invention has been described above with reference to the above embodiment. However, the present invention is not limited to the above embodiment. Various changes which one of ordinary skill in the art can understand can be applied to the configurations and the details of the present invention within the scope of the present invention.

For example, as disclosed in Non-Patent Literature 5 (3GPP TS 36.314 V10.2.0 (2011-09), 3GPP TSG RAN E-UTRAN Layer 2-Measurement, p. 9, p. 11, p. 15, September 2011), the allocation radio resource setting unit **204** can also calculate a delay index using the number of Active UEs, a delay time or a throughput per terminal instead of a PRB use ratio. The throughput per terminal is, for example, a size of data whose transmission to a terminal has succeeded during a connection time of the terminal. In addition, there are a method of directly notifying between base stations of these pieces of information and a method of connecting an OAM server onto the communication line NW and notifying these pieces of information through the OAM server to calculate a delay index using the number of Active UEs, the delay time or the throughput. In case of the latter, the OAM server has a function of counting the number of Active UEs, a delay time or a throughput per terminal from each pico base station **100** and each macro base station **200** connected to the communication line NW.

Further, the allocation radio resource setting unit **204** may calculate as a relative delay index of the pico base station **100-1** a ratio of a delay index of the macro base station **200-1** in case where radio resources whose use is limited have been set, with respect to a delay index of the pico base station **100-1** instead of calculating a difference value between a delay index of the pico base station **100-1** and a delay index of the macro base station **200-1** in case where the radio resources whose use is limited have been set.

Furthermore, the allocation radio resource setting unit **204** may also use a PRB use ratio as a load index of the macro base station **200-1** without using the number of transmitted bits TB_macro per RB of the macro base station **200-1**. Alternatively, the allocation radio resource setting unit **204** may also use the number of Active UEs as the load index of the macro base station **200-1**.

Further, the allocation radio resource setting unit **204** can also determine whether or not the macro base station **200-1** sets radio resources whose use is limited, without calculating the load index of the macro base station **200-1**. In this case, it is possible to skip step S**114** to step S**116** in FIG. **4** and, consequently, reduce a processing load of the macro base section **200-1** compared to the present embodiment.

Further, the present invention is also applicable even when a plurality of pico base stations are located in a communication area of a macro base station. In this case, the allocation radio resource setting unit **204** uses an average value of delay indices calculated per pico base station in the communication area or a predetermined value of a cumulative distribution as a delay index of the pico base station **100-1**.

Further, it is also possible to calculate the load index L_macro of the macro base station **200-1** according to equation 6B. In equation 6B, ΔS_ave represents an average value of data sizes which arrive at the transmitting buffer **205** of the macro base station **200-1** in the predetermined time T_subframe. According to equation 6B, it is possible to calculate as a load index of the macro base station **200-1** an estimated PRB use ratio which is a ratio of a total number of PRBs required until transmission of data which is being buffered in a transmitting buffer and data produced in the predetermined time T_subframe are finished, with respect to the total number of PRBs which can be used until the predetermined time T_subframe passes from a current time.

[Mathematical 8]

$$L\_macro=\mathrm{MIN}[1.0,\{(BS\_present+\Delta S\_ave)/TB\_macro\}/(N\_PRB\times T\_subframe)] \tag{6B}$$

In addition, ΔS_ave is updated according to equation 8 immediately before equation 6B is calculated. In equation 8, ΔS_ave_previous represents an average value of data sizes before an update, and ω represents a weight coefficient.

[Mathematical 9]

$$\Delta S\_ave=\omega\times\Delta S+(1-\omega)\times\Delta S\_ave\_previous \tag{8}$$

The above changes can be made likewise in the subsequent embodiments, too.

Second Embodiment

ABS Ratio is Directly Calculated Using Load

Next, the second embodiment of the present invention will be described in detail with reference to the drawings. Differences include that, while a ratio of radio resources whose use is limited is updated in predetermined step units according to a relative delay index of a pico base station **100-1** in the present embodiment, a ratio of radio resources whose use is limited is directly calculated using a relative delay index of the pico base station **100-1** in the present embodiment.

[Explanation of Configuration]

A pico base station according to the second embodiment is the same as a pico base station **100** according to the first embodiment, and therefore will not be described.

FIG. **6** is a block diagram illustrating functions of each macro base station **400** according to the second embodiment. The functions will be described using a macro base station **400-1** as a macro base station. Although not illustrated in FIG. **6**, functions of a macro base station **400-2** are the same as the functions of the macro base station **400-1**.

The macro base station **400-1** according to the second embodiment differs from a macro base station **200-1** according to the first embodiment in including an allocation radio resource setting unit **404** instead of an allocation radio resource setting unit **204**. The allocation radio resource setting unit **404** will be described below.

The allocation radio resource setting unit **404** has a function of calculating a ratio of radio resources whose use is limited using load information notified from the pico base station **100-1** and .a load of the macro base station **400-1** measured by a load measuring unit **203**. Further, the allocation radio resource setting unit **404** has a function of calculating a delay index for determining a delay time of a terminal of a pico base station **100-1** and a delay index indicating a delay time of the macro base station **400-1** which has set radio resources whose use is limited, respectively, using the calculated ratio of radio resources whose use is limited, the load information notified from the pico base station **100-1** and a load of the macro base station **400-1** measured by the load measuring unit **203**.

Furthermore, the allocation radio resource setting unit **404** has a function of calculating a load index of the macro base station **400-1** according to the same method as that of the allocation radio resource setting unit **204** according to the first embodiment. Still further, the allocation radio resource setting unit **404** has a function of determining whether or not to set radio resources whose use is limited by the macro base station **400-1** according to the same method as that of the allocation radio resource setting unit **204** according to the first embodiment, and notifying the pico base station **100-1** of a determination result referring to a surrounding base station list managed by a base station operating unit **201**.

In the present embodiment, radio resources whose use is limited are subframes of the macro base station **400-1**, and subframes whose use is limited are ABSs. When radio resources whose use is limited are set, the allocation radio resource setting unit **404** sets ABSs according to a same method as that of the allocation radio resource setting unit **204** according to the first embodiment using the calculated ABS ratio. Further, when radio resources whose use is limited are not set, the allocation radio resource setting unit **404** does not set ABSs. Furthermore, the allocation radio resource setting unit **404** uses ABS setting information to notify a determination result. In the ABS setting information, ABS patterns indicating that an ABS is 1 and a Non-ABS is 0 are described.

[Explanation of Operation]

FIG. **7** illustrates an operation procedure in which the allocation radio resource setting unit **404** of the macro base station **400-1** sets radio resources whose use is limited. The allocation radio resource setting unit **404** executes the operation illustrated in FIG. **7** at each cycle at which the load measuring unit **203** measures a PRB use ratio.

In view of FIG. **7**, step S**118** in FIG. **5** moves to a step before step S**101**. Further, step S**102** to step S**109** and step S**116** and step S**117** in FIG. **5** are omitted, and new step S**201** is added. Only the operation in added step S**201** will be described below.

The allocation radio resource setting unit **404** calculates an ABS ratio R_abs according to equation 9 using a PRB use ratio U_pico of the pico base station **100-1** notified from the pico base station **100-1**, and a PRB use ratio U_macro of the macro base station **400-1** measured by the load measuring unit **203** (step S**201**). In equation 9, R_max represents a maximum value of an ABS ratio, ΔD_target represents a target value of a relative delay index of the pico base station **100-1**, and w represents a weight coefficient. In the present embodiment, the weight coefficient w takes 1.0. Still further, FLOOR{t} represents a function of returning a maximum integer which does not exceed an argument t. Equation 9 is transformed into an equation of calculating the ABS ratio R_abs using equation 1 and equation 2 by replacing AD on a left side of equation 3 with ΔD_target (an equation which is not yet transformed is provided as equation 10). Consequently, using equation 9, the allocation radio resource setting unit **404** can calculate R_abs such that the relative delay index ΔD of the pico base station **100-1** takes the target value ΔD_target.

[Mathematical 10]

$$R\_abs=\mathrm{MAX}[R\_max,\mathrm{MIN}\ [0,\mathrm{FLOOR}\{8\times(1-w\times U\_macro)/(U\_pico-\Delta D\_target)\}/8]] \tag{9}$$

[Mathematical 11]

$$D\_target=D\_pico-D\_macro=U\_pico-w\times\{U\_macro/(1-R\_abs)\} \tag{10}$$

As described above, according to the pico base station **100-1** and the macro base station **400-1** according to the second embodiment of the present invention, when a load of the macro base station **400-1** is great, it is possible to directly calculate a ratio of radio resources whose use is limited such that a relative delay index of a pico base station **700-1** takes a target value. Consequently, a time which the ratio of radio resources whose use is limited takes to converge shortens compared to the first embodiment of the present invention. Further, the time which the ratio of the radio resources whose use is limited takes to converge is short. Consequently, it is possible to improve fairness between throughputs of all terminals **300** including terminals of the macro base station **400** and the pico base station **100** in a short time compared to the first embodiment of the present invention.

The present invention has been described above with reference to the above embodiment. However, the present invention is not limited to the above embodiment. Various changes which one of ordinary skill in the art can understand can be applied to the configurations and the details of the present invention within the scope of the present invention.

For example, a difference value between a delay index of the pico base station **100-1** and a delay index of the macro base station **400-1** in case where radio resources whose use is limited have been set is calculated as a relative delay index of the pico base station **100-1** in the present embodiment. However, a ratio of the delay index of the macro base station **400-1** in case where radio resources whose use is limited have been set, with respect to the delay index of the pico base station **100-1** may be calculated. In this case, the allocation radio resource setting unit **204** calculates the ABS ratio R_abs in step S**201** according to equation 11. Equation 11 is transformed into an equation of calculating the ABS ratio R_abs using equation 1 and equation 2 by replacing ΔD with ΔD_target in an equation of calculating as a relative delay index ΔD of the pico base station **100-1** a ratio of a delay index of the macro base station **200-1** in case where radio resources whose use is limited have been set, with respect to a delay index of the pico base station **100-1** (the equation which is not yet transformed is provided as equation 12). Even when a ratio of the delay indices is used, it is possible to perform control such that a relative delay index takes a target value. Consequently, it is possible to provide the same effect as that obtained when a difference between delay indices is used.

[Mathematical 12]

$$R\_abs=\mathrm{MAX}[R\_max,\mathrm{MIN}\ [0,\mathrm{FLOOR}\{8\times(U\_pico-w\times U\_macro\times\Delta D\_target)/U\_pico\}/8]] \tag{11}$$

[Mathematical 13]

$$\Delta D\_target=D\_pico/D\_macro=U\_pico/[w\times\{U\_macro/(1-R\_abs)\}] \tag{12}$$

The above changes can be made likewise in subsequent embodiments, too.

Third Embodiment

Limitation is Placed on Frequency

Next, the third embodiment of the present invention will be described in detail with reference to the drawings. The present embodiment differs from the second embodiment in changing radio resources whose use is limited from subframes to PRBs.

[Explanation of Configuration]

A pico base station according to the third embodiment is the same as a pico base station **100** according to the second embodiment, and therefore will not be described.

FIG. **8** is a block diagram illustrating functions of each macro base station **500** according to the third embodiment. The functions will be described using a macro base station **500-1** as a macro base station. Although not illustrated in FIG. **8**, functions of a macro base station **500-2** are the same as the functions of the macro base station **500-1**.

The macro base station **500-1** according to the third embodiment differs from a macro base station **400-1** according to the second embodiment in including an allocation radio resource setting unit **504** instead of an allocation radio resource setting unit **404**. The allocation radio resource setting unit **504** will be described below.

The allocation radio resource setting unit **504** has the same function as that of the allocation radio resource setting unit **404** according to the second embodiment. Meanwhile, radio resources whose use is limited are different from those of the allocation radio resource setting unit **404**.

In the present embodiment, radio resources whose use is limited are PRBs of the macro base station **500-1**, and, when it is determined that radio resources whose use is limited are set, PRBs which are not allocated to terminals are set in order from a PRB whose index is the smallest at a calculated ratio of radio resources whose use is limited.

[Explanation of Operation]

FIG. **10** illustrates an operation procedure in which the allocation radio resource setting unit **504** of the macro base station **500-1** sets radio resources whose use is limited. The allocation radio resource setting unit **504** executes the operation illustrated in FIG. **10** at each cycle at which a load measuring unit **203** measures a PRB use ratio.

In view of FIG. **10**, step S**201** in FIG. **7** is changed to step S**301**, step S**118** in FIG. **7** is changed to step S**302** and step S**108** in FIG. **7** is changed to step S**303**, respectively. Further, steps S**114**, S**115**, S**119** and S**120** in FIG. **7** are omitted, and step S**304** to step S**307** are added. Only the operations in step S**301** to step S**307** will be described below.

The allocation radio resource setting unit **504** calculates the number of PRBs N_prior which are not allocated to terminals according to equation 7 using a PRB use ratio

U_pico of a pico base station **100-1** notified from a pico base station **100-1** and a PRB use ratio U_macro of the macro base station **500-1** measured by the load measuring unit **203**. In equation 7, w represents a weight coefficient, and takes 1.0 in the present embodiment. The allocation radio resource setting unit **504** can calculate N_prior such that a delay target index ΔD of the pico base station **100-1** takes a target value ΔD_target using equation 7.

[Mathematical 14]

$$N\_prior=MAX[N\_PRB,MIN\ [0,FLOOR\{N\_PRB\times(1-w\times macro)/(U\_pico-\Delta D\_target)\}]] \quad (13)$$

Next, the allocation radio resource setting unit **504** determines whether or not calculated N_prior is a minimum value N_min or more (step **S302**). In the present embodiment, the minimum value N_min takes 1. When calculated N_prior is the minimum value N_min or more (step **S302**, Yes), the allocation radio resource setting unit **504** calculates a delay index D_pico of the pico base station **100-1** according to equation 1 (step **S101**), and then calculates a delay index D_macro in case where the macro base station **500-1** has set radio resources whose use is limited, using calculated N_prior according to equation 14 (step **S303**). In equation 14, w represents a weight coefficient, and takes 1.0 in the present embodiment.

[Mathematical 15]

$$D\_macro=w\times[U\_macro/\{1-(N\_prior/N\_PRB)\}] \quad (14)$$

Further, when determining that a load index L_macro of the macro base station **500-1** calculated in step S**115** is a threshold L_Thr or more (step S**113**, Yes), the allocation radio resource setting unit **504** determines whether or not calculated N_prior is the same as a current setting value (step S**304**).

When calculated N_prior is the same as the current setting value (step S**304**, Yes), the allocation radio resource setting unit **504** finishes the processing in FIG. **10**. Meanwhile, when calculated N_prior is different from the current setting value (step S**304**, No), the allocation radio resource setting unit **504** sets PRBs which are not allocated to terminals using calculated N_prior (step S**306**). Subsequently, the allocation radio resource setting unit **504** finishes the processing in FIG. **10**.

Further, when determining that the load index L_macro of the macro base station **500-1** calculated in step S**112** is less than the threshold L_Thr (step S**113**, No), the allocation radio resource setting unit **504** determines whether or not PRBs which are not allocated to terminals are set (step S**306**).

When PRBs which are not allocated to terminals are set (step S**306**, Yes), the allocation radio resource setting unit **504** cancels the set PRBs which are not allocated to the terminals (step S**307**). Subsequently, the allocation radio resource setting unit **504** finishes the processing in FIG. **10**. Meanwhile, when PRBs which are not allocated to terminals are not set (step S**308**, No), the allocation radio resource setting unit **504** finishes the processing in FIG. **10**. Further, when calculated N_prior is less than the minimum value N_min (step S**302**, No), the allocation radio resource setting unit **504** moves to step S**306**.

The present invention has been described above with reference to the above embodiment. However, the present invention is not limited to the above embodiment. Various changes which one of ordinary skill in the art can understand can be applied to the configurations and the details of the present invention within the scope of the present invention.

For example, the allocation radio resource setting unit **504** can also update the number of RBs which are priority bands of the pico base station **100-1** such that a difference value between a delay index of the pico base station **100-1** and a delay index of the macro base station **500-1** which has set radio resources whose use is limited settles in a predetermined range according to the same method as that in the first embodiment. The above changes can be made likewise in the subsequent embodiments, too.

Fourth Embodiment

Pico Base Station Calculates ABS Ratio, and Notifies Macro Base Station of ABS Ratio

Next, the fourth embodiment of the present invention will be described in detail with reference to the drawings. Differences include that, while a macro base station sets a ratio of radio resources whose use is limited and notifies a pico base station of this setting information in the second embodiment, a pico base station requests radio resources whose use is limited by the macro base station, and the macro base station sets radio resources whose use is limited according to the request from the pico base station in the present embodiment.

[Explanation of Configuration]

FIG. **11** is a block diagram illustrating functions of each pico base station **600** and each macro base station **700** according to the fourth embodiment. The functions will be described using a pico base station **600-1** as a pico base station and a macro base station **700-1** as a macro base station. Although not illustrated in FIG. **11**, functions of a pico base station **600-2** are the same as the functions of the pico base station **600-1**. Similarly, functions of a macro base station **700-2** are the same as the functions of the macro base station **700-1**.

The pico base station **600-1** according to the fourth embodiment differs from a pico base station **100-1** according to the second embodiment in additionally including a priority resource requesting unit **604**. Further, the macro base station **700-1** according to the fourth embodiment differs from a macro base station **400-1** according to the second embodiment in including an allocation radio resource setting unit **704** instead of an allocation radio resource setting unit **204**. The priority resource requesting unit **606** and the allocation radio resource setting unit **704** will be described below.

The priority resource requesting unit **606** has a function of calculating a ratio of radio resources whose use is limited using a load of the pico base station **600-1** measured by a load measuring unit **103** and load information notified from the macro base station **700-1**. Further, the priority resource requesting unit **606** has a function of calculating a delay index for determining a delay time of a terminal of the pico base station **600-1** and a delay index indicating a delay time of the macro base station **700-1** in case where radio resources whose use is limited have been set, respectively, using the calculated ratio of radio resources whose use is limited, a load of the pico base station **600-1** measured by the load measuring unit **103**, and the load information notified from the macro base station **700-1**. Furthermore, the priority resource requesting unit **606** has a function of calculating the load index of the macro base station **400-1** using the load information notified from the macro base station **700-1**. Still further, the priority resource requesting unit **606** has a function of determining whether or not to request priority resources of the pico base station **600-1**, to the macro base station based on the calculated delay index of the pico base station **600-1** and the calculated delay index and load index of the macro base station **700-1**, and has a function of notifying the macro base station **700-1** of a determination result referring to a surrounding base station list managed by a base station operating unit **101**.

In the present embodiment, radio resources whose use is limited are ABSs of the macro base station **700-1**, and ABS setting information is used to notify a determination result. The ABS setting information is generally used to notify that a base station which has set ABSs has set ABSs to surrounding base stations. However, a pico base station uses ABS setting information to request a macro base station to set ABSs in the present embodiment. In the ABS setting information, ABS patterns indicating that an ABS is 1 and a Non-ABS is 0 are described. When requesting priority resources to the macro base station **700-1**, the priority resource requesting unit **606** describes a request for priority resources in ABS setting information for setting ABSs according to the same method as that of the allocation radio resource setting unit **204** according to the first embodiment using the calculated ABS ratio. Further, when not requesting priority resources to the macro base station **700-1**, the priority resource requesting unit **606** describes information indicating that all subframes are Non-ABSs, in the ABS setting information.

The allocation radio resource setting unit **704** has a function of setting radio resources whose use is limited according to the ABS setting information notified from the pico base station **600-1**. In the present embodiment, the radio resources whose use is limited are subframes of the macro base station **200-1**, and subframes whose use is limited are ABSs. When setting radio resources whose use is limited, the allocation radio resource setting unit **704** sets ABSs according to a pattern instructed by the pico base station **600-1**. Further, when not setting radio resources whose use is limited, the allocation radio resource setting unit **704** does not set ABSs.

[Explanation of Operation]

FIG. **12** illustrates an operation procedure in which the priority resource requesting unit **606** of the pico base station **600-1** determines whether or not to request the macro base station **700-1** to set radio resources whose use is limited. The priority resource requesting unit **606** executes the operation illustrated in FIG. **12** at each cycle at which the load measuring unit **103** measures a PRB use ratio.

In FIG. **12**, step S**111** and step S**112** in FIG. **7** are changed to step S**401**. Further, steps S**114**, S**115**, S**119** and S**120** in FIG. **7** are omitted, and step S**402** and step S**403** are added. Only operations subsequent to step S**401** will be described below.

The priority resource requesting unit **606** calculates a load index L_macro of the macro base station **700-1** according to equation 15 using the PRB use ratio notified from the macro base station **700-1** (step S**401**).

[Mathematical 16]

$$L\_macro = U\_macro \quad (15)$$

Next, the priority resource requesting unit **606** determines whether or not the calculated load index L_macro of the macro base station **700-1** is a threshold L_Thr or more (step S**116**).

When the calculated load index L_macro is the threshold L_Thr or more (step S**113**, Yes), the priority resource requesting unit **606** determines that a transmission probability of the macro base station **700-1** is high, and a probability that a pico terminal **300**-P**1** receives an interference from the macro base station **700-1** is high, too, and notifies the macro base station **700-1** of ABS setting information for setting ABSs set using an ABS ratio R_abs calculated in step S**201** (step S**402**). Subsequently, the priority resource requesting unit **606** finishes the processing in FIG. **10**.

When the calculated load index L_macro is less than the threshold L_Thr (step S**116**, No), the priority resource requesting unit **606** determines that a transmission probability of the macro base station **700-1** is low, and a probability that a pico terminal **300**-P**1** receives an interference from the macro base station **700-1** is low, too, and notifies the macro base station **700-1** of the ABS setting information indicating that all subframes are Non-ABSs. Subsequently, the priority resource requesting unit **606** finishes the processing in FIG. **10**.

FIG. **13** illustrates an operation procedure in which the allocation radio resource setting unit **704** of the macro base station **700-1** sets radio resources whose use is limited according to ABS setting information from the pico base station **600-1**. The allocation radio resource setting unit **704** executes the operation illustrated in FIG. **13** every time the allocation radio resource setting unit **704** receives RNTP from the pico base station **600-1**.

First, the allocation radio resource setting unit **704** determines whether or not the ABS ratio R_abs described in the ABS setting information notified from the pico base station **600-1** to the macro base station **700-1** is larger than 0 (step S**501**).

When the ABS ratio R_abs is larger than 0 (step S**501**, Yes), the allocation radio resource setting unit **704** determines whether or not R_abs is the same as a current setting value (step S**114**).

When R_abs is the same as the current setting value (step S**114**, Yes), the allocation radio resource setting unit **704** finishes the processing in FIG. **13**. Meanwhile, when R_abs is different from the current setting value (step S**114**, No), the allocation radio resource setting unit **704** sets ABSs at R_abs (step S**502**). Subsequently, the allocation radio resource setting unit **704** finishes the processing in FIG. **13**.

Further, when the ABS ratio R_abs is 0 (step S**501**, No), the allocation radio resource setting unit **704** determines whether or not the macro base station **700-1** has already set ABSs (step S**119**). In case where the macro base station **700-1** has already set ABSs (step S**119**, Yes), the allocation radio resource setting unit **704** cancels the set ABSs (step S**503**). Subsequently, the allocation radio resource setting unit **704** finishes the processing in FIG. **13**. Meanwhile, in case where the macro base station **700-1** has not set ABSs (step S**119**, No), the allocation radio resource setting unit **704** finishes the processing in FIG. **13**.

The present invention has been described above with reference to the above embodiment. However, the present invention is not limited to the above embodiment. Various changes which one of ordinary skill in the art can understand can be applied to the configurations and the details of the present invention within the scope of the present invention.

For example, the allocation radio resource setting unit **704** cancels a limitation placed on set radio resources whose use is limited when ABS setting information indicating that the ABS ratio is 0 is notified from the pico base station **600-1**. However, a limitation on radio resources may be canceled when a predetermined time passes after setting the radio resources whose use is limited is started. In this case, the priority resource requesting unit **606** can skip the processing in step S**403**. Consequently, it is possible to reduce a processing load of the pico base station **600-1** compared to the present embodiment. Further, the pico base station **600-1** only needs to notify ABS setting information in case where the macro base station **700-1** sets radio resources whose use is limited. Consequently, it is possible to suppress a signaling amount between base stations through a communication line NW compared to the present embodiment.

Furthermore, ABSs are set by setting radio resources whose use is limited in the present embodiment. However, similar to the third embodiment, it is also possible to set to each terminal **300-M1** an allocatable band as a band formed by excluding a priority band of the pico base station **600-1** from a system band. In this case, the priority resource requesting unit **606** calculates the number of RBs which are priority bands of the pico base station **600-1** according to the same method as that of an allocation radio resource setting unit **504** of a macro base station **500-1** according to the third embodiment, and notifies the macro base station **700-1** of a calculation result. RNTP is used to notify a calculation result. 1 is set to RNTP in a RB (Resource block) which is requested as a priority band, and 0 is set to RNTP in a RB which is not requested as a priority band. A RB represents a frequency block which is a radio band allocation unit.

Further, the present invention is also applicable even when a plurality of pico base stations are located in a communication area of a macro base station. In this case, the allocation radio resource setting unit **704** calculates a rate of the number of pico base stations which have notified ABS setting information indicating that an ABS ratio is larger than 0, with respect to a total number of base stations in a communication area, and sets ABSs according to ABS setting information of the lowest ABS ratio among ABS ratios which are larger than 0 only when the rates are a threshold of the rates or more. Alternatively, the allocation radio resource setting unit **704** can also set ABSs to subframes whose ABSs overlap among a plurality of pieces of ABS setting information.

In addition, the present invention is not limited to the above embodiments, and can be optionally changed without departing from the spirit of the present invention.

Although the present invention has been described as a hardware configuration in the above embodiments, the present invention is not limited to these. The present invention can also be realized by causing a CPU (Central Processing Unit) to execute a computer program to perform the processing in a terminal or a base station. In this case, the computer program can be supplied to the computer by being stored using various types of non-transitory computer readable media. The non-transitory computer readable media include various types of tangible storage media. The non-transitory computer readable media include, for example, magnetic recording media (e.g. flexible disks, magnetic tapes and hard disk drives), magnetooptical recording media (e.g. magnetooptical disks), CD-ROMs (Read Only Memory), CD-Rs, CD-R/Ws, and semiconductor memories (e.g. mask ROMs, PROMs (Programmable ROM), EPROMs (Erasable PROM), flash ROMs and RAMs (Random Access Memory)). Further, the program may be supplied to the computer using various types of transitory computer readable media. The transitory computer readable media include, for example, electric signals, optical signals and electromagnetic waves. The transitory computer readable media can supply the program to the computer using wired communication channels such as electric wires and optical fibers or wireless communication channels.

Although the present invention has been described above with reference to the embodiments, the present invention is by no means limited to the above embodiments. Various changes which one of ordinary skill in the art can understand can be applied to the configurations and the details of the present invention within the scope of the invention.

This application claims priority to Japanese Patent Application No. 2012-246962 filed on Nov. 9, 2012, the entire contents of which are incorporated by reference herein.

REFERENCE SIGNS LIST

10 RADIO COMMUNICATION SYSTEM
100-1, **100-2**, **600-1** PICO BASE STATION
200-1, **200-2**, **400-1**, **500-1**, **700-1** MACRO BASE STATION
300-P1-1, **300-P1-2**, **300-P2-1**, **300-P2-2**, **300-M1-1**, **300-M1-2**, **300-M2-1**, **300-M2-2** TERMINAL
101, **201** BASE STATION OPERATING UNIT
102, **202** REFERENCE SIGNAL GENERATING UNIT
103, **203** LOAD MEASURING UNIT
104, **205** TRANSMITTING BUFFER
105, **206** SCHEDULER
606 PRIORITY RESOURCE REQUESTING UNIT
204, **404**, **504**, **704** ALLOCATION RADIO RESOURCE SETTING UNIT
301 TERMINAL OPERATING UNIT
302 CHANNEL QUALITY MEASURING UNIT

What is claimed is:

1. A radio resource setting method for, when there are a first communication area managed by a first base station and a second communication area including at least part of the first communication area and managed by a second base station, setting radio resources that the first and second base stations can use for wireless communication with a terminal, the radio resource setting method comprising:

obtaining loads of the first communication area and the second communication area;

calculating a first delay index of the first communication area using the load of the first communication area;

calculating using the load of the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set;

calculating a ratio of radio resources whose use is limited in the second communication area based on the first delay index and the second delay index; and

setting the radio resources whose use is limited in the second communication area using the ratio of the radio resources whose use is limited.

2. The radio resource setting method according to claim **1**, further comprising, upon calculation of the ratio of the radio resources whose use is limited, calculating a relative delay index that is a difference between or a ratio of the first delay index and the second delay index,

wherein the ratio of the radio resources whose use is limited

is updated to a value that is a predetermined addition step larger than a latest ratio of the radio resources whose use is limited when the relative delay index is larger than a first threshold of the relative delay index, and

is updated to a value that is a predetermined subtraction step smaller than the latest ratio of the radio resources whose use is limited when the relative delay index is smaller than a second threshold of the relative delay index.

3. The radio resource setting method according to claim **1**, wherein the ratio of the radio resources whose use is limited is calculated using the first delay index, the second delay index and a difference between or a ratio of the first delay index and the second delay index.

4. The radio resource setting method according to claim 1, wherein the load is a band use ratio.

5. The radio resource setting method according to claim 1, wherein the load is a number of terminals.

6. The radio resource setting method according to claim 1, wherein the load is a delay time of the terminal.

7. The radio resource setting method according to claim 1, wherein the load is a throughput of the terminal.

8. The radio resource setting method according to claim 1, wherein the second base station calculates the ratio of the radio resources whose use is limited in the second communication area.

9. The radio resource setting method according to claim 1, wherein the first base station calculates the ratio of the radio resources whose use is limited in the second communication area, and notifies the second base station of a result of the calculation.

10. A base station that performs wireless communication with a terminal in a second communication area that is at least one of a neighboring communication area of a first communication area or a communication area including part of the first communication area, the base station comprising:

a load measuring unit that measures a load of the second communication area; and

an allocation ratio resource setting unit that calculates a first delay index of the first communication area using the load of the first communication area notified from an other base station that manages the first communication area,

calculating using the load of the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set, and

calculating a ratio of radio resources whose use is limited in the second communication area based on the first delay index and the second delay index.

11. The base station according to claim 10, wherein the allocation radio resource setting unit calculates a relative delay index that is a difference between or a ratio of the first delay index and the second delay index, and updates the ratio of the radio resources whose use is limited, to a value that is a predetermined addition step larger than a latest ratio of the radio resources whose use is limited when the relative delay index is larger than a first threshold of the relative delay index, and

updates the ratio of the radio resources whose use is limited, to a value that is a predetermined subtraction step smaller than the latest ratio of the radio resources whose use is limited when the relative delay index is smaller than a second threshold of the relative delay index.

12. The base station according to claim 10, wherein the allocation radio resource setting unit calculates the ratio of the radio resources whose use is limited using the first delay index, the second delay index and a difference between or a ratio of the first delay index and the second delay index.

13. The base station according to claim 10, wherein the load is a band use ratio.

14. The base station according to claim 10, wherein the load is a number of terminals.

15. The base station according to claim 10, wherein the load is a delay time of the terminal.

16. The base station according to claim 10, wherein the load is a throughput of the terminal.

17. A base station that, when there is a second communication area that is at least one of a neighboring communication area of a first communication area or a communication area including part of the first communication area, performs wireless communication with a terminal in the first communication area, the base station comprising:

a load measuring unit that measures a load of the first communication area; and

a priority resource requesting unit that calculates a first delay index of the first communication area using the load of the first communication area,

calculating using the load of the second communication area transmitted from an other base station that manages the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set, and

calculating a ratio of radio resources whose use is limited in the second communication area based on the first delay index and the second delay index, and notifying the other base station that manages the second communication area of a result of the calculation.

18. The base station according to claim 17, wherein the priority resource requesting unit calculates a relative delay index that is a difference between or a ratio of the first delay index and the second delay index, and updates the ratio of the radio resources whose use is limited, to a value that is a predetermined addition step larger than a latest ratio of the radio resources whose use is limited when the relative delay index is larger than a first threshold of the relative delay index, and

updates the ratio of the radio resources whose use is limited, to a value that is a predetermined subtraction step smaller than the latest ratio of the radio resources whose use is limited when the relative delay index is smaller than a second threshold of the relative delay index.

19. The base station according to claim 17, wherein the priority resource requesting unit calculates the ratio of the radio resources whose use is limited using the first delay index, the second delay index and a difference between or a ratio of the first delay index and the second delay index.

20. The base station according to claim 17, wherein the load is a band use ratio.

21. The base station according to claim 17, wherein the load is a number of terminals.

22. The base station according to claim 17, wherein the load is a delay time of the terminal.

23. The base station according to claim 17, wherein the load is a throughput of the terminal.

24. A radio resource setting system that, when there are a first communication area managed by a first base station and a second communication area including at least part of the first communication area and managed by a second base station, sets radio resources that the first and second base stations can use for wireless communication with a terminal, wherein the radio resource setting system is configured to:

obtain loads of the first communication area and the second communication area;

calculate a first delay index of the first communication area using the load of the first communication area;

calculate using the load of the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set;

calculate a ratio of the radio resources whose use is limited in the second communication area based on the first delay index and the second delay index; and

set the radio resources whose use is limited in the second communication area using the ratio of the radio resources whose use is limited.

25. A non-transitory computer readable medium having stored thereon a program that is executed by a computer of a base station that performs wireless communication with a terminal in a second communication area that is at least one of a neighboring communication area of a first communication area or a communication area including part of the first communication area, the program causing the computer to execute:

obtaining a load of the second communication area;

calculating a first delay index of the first communication area using a load of the first communication area notified from an other base station that manages the first communication area;

calculating using the load of the second communication area a second delay index of the second communication area in case where the radio resources whose use is limited in the second communication area have been set; and

calculating a ratio of the radio resources whose use is limited in the second communication area based on the first delay index and the second delay index.

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